FEASIBILITY STUDY REPORT
CEDAR CHEMICAL CORPORATION
HELENA-WEST HELENA, ARKANSAS

Submitted to:

ExxonMobil Corporation and Helena Chemical Company

Submitted by:

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The report entitled "Feasibility Study Report" dated December 2009 was prepared on behalf of ExxonMobil Chemical Company and Helena Chemical Company. The report was prepared under the supervision of the undersigned Arkansas Register Professional Geologist.

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1.0 INTRODUCTION

This Feasibility Study (FS) presents an evaluation of remedy alternatives and a recommendation for remedy selection in order to address the presence of elevated Constituents of Concern (COCs) at the former Cedar Chemical Corporation Facility ("the Facility"). The Facility is located in the Helena-West Helena Industrial Park approximately 1.25 miles southwest of the intersection of U.S. Highway 49 and State Highway 242, in Phillips County, Arkansas (Figure 1). The evaluation of remedy alternatives and the remedy recommendations were based on the results of previous investigations and a risk screening of COCs in soil and groundwater.

On March 22, 2007, the Arkansas Department of Environmental Quality (ADEQ) issued a Consent Administrative Order (CAO) regarding environmental conditions at the Facility to Ansul, Inc., formerly known as Wormald US, Inc., Helena Chemical Company (Helena), and ExxonMobil Chemical Company (ExxonMobil), a division of Exxon Mobil Corporation, pursuant to the authority of the Arkansas Remedial Action Trust Fund Act ("RATFA"). The stated objective of the CAO is to "address environmental concerns at the Facility to ensure protection of human health and the environment." The CAO requires these companies to perform various tasks with respect to environmental conditions at the Facility.

Pursuant to Paragraph V. 20 of the CAO, Helena and ExxonMobil (hereafter the Group), acting jointly, entered into a Separate Agreement with ADEQ on March 25, 2008. Although Ansul, Inc. signed the CAO, it is not a party to the Separate Agreement and it has not contributed to any work described in this report. This Separate Agreement stipulated that a site investigation and feasibility study (FS) process would be accomplished through the completion and submittal of the following:

- A Current Conditions Report (CCR), compiling available information and data for the Facility, to ADEQ. This CCR was submitted on November 16, 2007.

- A Facility Investigation (FI) Work Plan to ADEQ. This work plan was submitted on January 18, 2008, re-submitted on March 20, 2008 with revisions based on ADEQ comments, and conditionally approved by ADEQ on March 25, 2008. A supplement to the FI Work plan, describing additional well installations, was submitted to ADEQ on August 28, 2008, and approved by ADEQ on September 5, 2008.

- The FI activities described in the FI Work plan. The planned field work was completed in August 2008.

- A Preliminary FI Report. This report was submitted to ADEQ on October 13, 2008.

- An FI Report. This report was submitted to ADEQ on February 24, 2009, and replacement pages addressing the ADEQ comments were submitted to ADEQ on May 29, 2009. ADEQ approved the revised FI Report in a letter dated June 4, 2009.

- An FS based on FI findings. This document was prepared and originally submitted to ADEQ on August 11, 2009. ADEQ issued comments on September 10 2009 and October 28, 2009. This revised FS is being submitted on behalf of the Group to satisfy all of the ADEQ comments and this requirement.

2.0 BACKGROUND INFORMATION

The Facility was constructed in 1970 and operated until 2002. There have been no production operations at the Facility since 2002. When the Facility was active, operations were primarily the manufacture and blending of pesticides, herbicides, and specialty chemicals.

The Facility is located to the south of the city of Helena-West Helena, in Phillips County, Arkansas, and consists of 48 acres within the Helena-West Helena Industrial Park (the Industrial Park) approximately 1.25 miles southwest of the intersection of U.S. Highway 49 and State Highway 242. Figure 1 illustrates the location of the Facility. The Facility is bordered by farmland, State Highway 242, a rail spur, and Industrial Park properties.

The former operational portion of the property is divided into two major areas:

- Approximately 40 acres comprising the abandoned manufacturing area, on the north side of Industrial Park Road, and

- Approximately 8 acres comprising the current wastewater treatment pond area, on the south side of Industrial Park Road.

An undeveloped, wooded area west of the wastewater treatment pond area and south of Industrial Park Road is also part of the site property, but does not appear to have historically been part of the manufacturing facility. Figure 2 illustrates the locations of process units and other salient site features.

The Site is underlain by several units of unconsolidated Quaternary and Tertiary age sedimentary deposits. There are two shallow groundwater units at the site:

- The Perched Zone, present within low-permeability silt and clay surficial sediments (ground surface to approximately 30 to 40 feet below ground surface [bgs]) and

- The Alluvial Aquifer, extending from approximately 40 to 150 feet bgs.

The Alluvial Aquifer is, in turn, underlain by the Jackson-Claiborne Group (which includes the Jackson Clay), which is approximately 250 feet thick in the site area. The Jackson-Claiborne Group is a thick, low permeability stratum comprised of clay and lignite that acts as a regional confining unit beneath the Alluvial Aquifer.

3.0 SUMMARY OF FACILITY INVESTIGATION FINDINGS

There was extensive investigative work performed at the Facility prior to the FI. This included, but is not limited to:

- A 1988 hydrogeologic assessment by Grubbs, Garner & Hoskyn,
- Multiple episodes of soil and groundwater assessment by EnSafe in 1993 to 1995,
- A risk assessment by EnSafe in 2001 and 2002, and
- A 2005 groundwater monitoring event performed jointly by ADEQ and the U.S. Environmental Protection Agency (USEPA) Region 6.

More detailed discussions of the scope and findings of this previous work are provided in the CCR submitted to ADEQ in November 2007. The CCR also includes information regarding the Facility's setting, past environmental conditions, historical ownership, and surroundings.

The FI was conducted to supplement the previous investigative work, by addressing gaps in the existing assessment data, updating the understanding of groundwater conditions, and developing information needed to support remedy selection. FI investigation work, including soil borings, cone-penetrometer studies, new monitoring well installation, soil and groundwater sampling, and aquifer testing, was performed predominantly between March and November 2008. The results were submitted to the ADEQ in the FI Report and FI Supplemental Information dated February and June 2009, respectively.

The FI findings were used to identify chemical constituents present in on-site soil and in on-site and off-site groundwater. The primary constituents detected were volatile and semivolatile organic constituents, metals, pesticides and herbicides. In addition, the FI further delineated the distribution and magnitude of the predominant chemical constituents in soil and groundwater; these data were used to identify likely source areas for these compounds.

The primary conclusions of the FI were:

- On-site soils in the former Process Areas are impacted by volatile organic constituents (VOCs), semivolatile organic constituents (SVOCs), pesticides and herbicides, and possibly low levels of certain metals.
- Advective groundwater flow within the shallower Perched Zone and related lateral transport of the observed chemicals in this zone's groundwater is limited by the low hydraulic conductivity of this zone.

- The deeper Alluvial Aquifer is highly transmissive, with groundwater flowing generally from the Facility toward the Industrial Park and agricultural properties to the south and southeast.

- Certain chemical constituents are migrating vertically through leakage from the Perched Zone to the Alluvial Aquifer. Based on the contrast in chemical concentrations between these two zones, most of the contaminant mass is likely being retained in the low permeability soils of the perched zone.

- The primary groundwater constituents observed above screening levels in Perched Zone groundwater were 1,2-dichloroethane (1,2-DCA), 1,2-dichlorobenzene (1,2-DCB), dinoseb, 4-chloroaniline, toluene, and acetone.

- In the Alluvial Aquifer, the primary groundwater constituents observed above screening levels were 1,2-DCA, 1,2 DCB, bis(2-chloroethyl) ether, and 4-chloroaniline.

- With the exception of on-site or nearby off-site areas within the Industrial Park, the primary Alluvial Aquifer groundwater COC that exceeds its screening level was 1,2-DCA. 1,2-DCA has been documented to be present at least 2,700 feet downgradient of the Facility boundary, beyond the southern end of the Industrial Park. Updated delineation of the boundary of 1,2-DCA beyond the Industrial Park was not undertaken during the FI because of litigation filed by the subject property owner.

- The most significant source areas for the chemicals observed in the Perched Zone and Alluvial Aquifer are Process Areas and waste disposal areas, especially the vicinity of the Former Dinoseb Disposal Ponds.

- The Drum Vault contains highly dilapidated drums of unknown products or wastes; the vault also contains sand backfill and water. The backfill and water exhibit elevated levels of various VOCs, SVOCs, pesticides, and herbicides.

- Agricultural supply wells have been identified downgradient of the property. No downgradient water supply wells have been identified near the Facility that would be used for drinking water or domestic supply.

Many of the compounds that have historically been detected in Alluvial Aquifer groundwater were not detected during the FI. Those compounds that were detected were generally present at concentrations well below historic maxima. Based on these trends, both the mass and concentrations of chemicals present in the Alluvial Aquifer have declined since operations ceased at the Facility.

4.0 REMEDY OBJECTIVES

Remedy objectives were established based on the results of the FI and risk-screening evaluation, taking into consideration key chemical constituents and their migration and exposure pathways, potential receptor points and anticipated future site use. The remedy objectives establish the expectations for the remedy's direction and performance, and provide metrics for its short-term and long-term effectiveness.

The remedy objectives identified for the Facility are as follows:

- Protect the health of the public, site workers, and others that may be present at the Facility or in its environs, given its expected mode of future use, by controlling current and future exposures to soils and groundwater that contain COCs at concentrations above risk screening criteria.

- Accelerate the natural attenuation processes in the Alluvial Aquifer by reducing on-site sources of chemicals in both shallow soils and the Perched Zone, thereby reducing both the size and duration of the Alluvial Aquifer plume.

- Enhance the future usability of the site by establishing controls that are compatible with a range of commercial or industrial uses, within reasonable limitations, and that avoid activities or uses that would compromise public safety or the effectiveness of on-going remedy controls.

- Leave the Facility property in a condition such that storm water runoff is suitable for discharge either with minimal or no treatment. This will require that contact between storm water and contaminated media be reduced.

The remedy alternatives discussed in Section 6.0 of this FS were evaluated relative to their effectiveness in meeting these objectives.

These objectives consider the reasonable anticipated future land use for the Facility. This land use is anticipated to be commercial or industrial in character. As discussed in Section 6.0, some of the remedy alternatives under consideration would require future users to avoid activities that will disturb or expose in-place soils or groundwater, or that remove or disrupt the engineering controls implemented at the Facility. Given this, examples of industrial use that could be compatible with the anticipated future condition of the Facility could include:

- Truck terminal

- Cargo storage or transshipment

- Vehicle storage or parking
- Propane or LP Gas storage and distribution
- Warehousing

Many forms of commercial usage would be possible, as long as buildings and other improvements to support that use could be constructed in a manner that was compatible with the selected remedy.

5.0 HUMAN HEALTH RISK SCREENING ANALYSIS

A risk-based screening analysis of site soils and groundwater was prepared by the Center for Toxicology and Environmental Health (CTEH) and is included in Appendix A. This analysis performed a comparison of chemical constituents in on-site soils and on and off-site groundwater to USEPA 2007 generic screening values. It also included an exposure assessment to evaluate potential pathways of human exposure to these chemicals, and to calculate risk-based concentrations for potential receptors. The potential exposure pathways identified for each Facility media are:

- On-Site Soils
  - ◊ Direct contact (combined contact, ingestion, and inhalation pathways)
  - ◊ Vapor Intrusion
- Perched Zone Groundwater
  - ◊ Vapor Intrusion
- Alluvial Aquifer Groundwater
  - ◊ Total Exposure (Ingestion)

Information regarding exposure pathways and assessment, data evaluation, selection of chemicals of potential concern (COPCs), and development and comparison of COPCs that exceed a risk-based concentration (i.e., chemicals of concern, or COCs) are discussed in the CTEH report (Appendix A). The distribution of exceeding COCs are illustrated in Figures 3 and 4 (on-site soils), 5 (Perched Zone groundwater), and 6 (Alluvial Aquifer groundwater).

6.0 SOIL AND GROUNDWATER REMEDY RECOMMENDATIONS

As discussed in Section 5.0, Facility-sourced COCs are present at levels that exceed risk-based criteria in a number of locations at the Facility and in the surrounding area. The media affected by these COCs are unsaturated zone soils, Perched Zone groundwater, and Alluvial Aquifer groundwater. AMEC has identified a series of remedy alternatives for each of these three affected media. These alternatives are discussed in detail in Sections 6.1 (Soils), 6.2 (Perched Zone groundwater), and 6.3 (Alluvial Aquifer groundwater) of this FS.

For each remedy alternative, the following is provided:

- A brief narrative description of the remedy alternative, including the manner in which it would be implemented at the Facility. These include some basic assumptions about the scope of the remedy alternative.

- A discussion of the effectiveness of the remedy alternative in meeting the remedy objectives discussed in Section 4.0, over both the short and long term. In the context of this discussion, a remedy alternative will be considered effective if it is likely to either reduce COC concentrations below applicable RBCs, or to render an exposure pathway involving those COCs incomplete over either the short- or long-term.

- The estimated cost to implement the remedy alternative, broken down by capital costs (i.e., the cost to perform the initial installation, construction, or related activity to bring the remedial alternative on line), operations and maintenance costs on a per annum basis, and costs to decommission any infrastructure or facilities associated with the remedial alternative after operations have concluded. The development of these costs is tabulated in Table 1, with a more detailed breakdown provided in Appendix B. Please note that costs can vary considerably depending on exactly how and when the remedy alternative is implemented. The cost estimate provided is based on the scope of implementation described in this FS, as well as any more detailed assumptions described in Appendix B.

Where appropriate, figures depicting the conceptual layout or locations of key features of each remedy alternative are also provided.

In Section 6.4, AMEC presents a recommendation for the suite of remedies to be selected by ADEQ for implementation, and describes the rationale supporting this recommendation.

6.1 ON-SITE SOILS

Based on samples collected during both the FI and previous investigations, and as discussed in Section 5.0 and Appendix A, COCs are present in some on-site soils above risk-based screening levels for both the direct exposure and vapor intrusion pathways. Direct contact would include those exposures related to immediate or near contact with soils: inhalation of dust or vapors, absorption through the skin or mucous membranes, and ingestion of soils. Vapor intrusion exposures would result from the evaporation of volatile COCs from the soils, and the subsequent accumulation of vapors in indoor air spaces used by personnel. The COCs that are present in on-site soils at concentrations above direct contact RBCs are dieldrin, dinoseb, and aldrin; the COCs exceeding vapor intrusion RBCs are chloroform and 1,2-dichloroethane (1,2-DCA). Figure 3 (vapor intrusion) and 4 (direct contact) illustrate the locations where these exceedances are present.

Most of these soil exceedances underlie the Process Areas of the Facility, although there are a few in other areas. Within the Process Areas, these exceedances exhibit a generally scattered distribution. This distribution is consistent with the these COCs having been sourced from multiple releases at different locations within the Facility.

Despite the generally scattered distribution of COCs at elevated concentrations, there is a significant locus of exceedances in the vicinity of the Former Dinoseb Disposal Ponds, near the Pump Shop. In addition, Perched Zone groundwater exhibits the highest observed concentrations of 1,2-DCA beneath the former Dichloroaniline Unit (Unit 6) (Figure 5), which indicates the likely presence of elevated 1,2-DCA in soils beneath this unit.

Given the suspected nature of Facility releases (i.e., multiple releases from varied source areas) it is likely that there are localized areas of elevated COCs in soils across the Facility, including areas not previously observed during historical or recent investigative work. The potential presence of such "pockets" of elevated COCs should be considered during the remedy evaluation and selection process.

The following remedy alternatives were evaluated for soils:

Soil Remedy Alternative S1—Exposure Control—Reducing the potential for workers and the public to be exposed to soils through a combination of institutional and engineering controls.

Soil Remedy Alternative S2—*In Situ* Stabilization—Reducing the potential leachability and mobility of soil constituents in selected geographic areas by mixing the soils in place with a stabilizing material.

Soil Remedy Alternative S3—Excavation with Off-Site Disposal as Solid Waste—Removing contaminated soils from the Facility, and replacing them with clean backfill.

Soil Remedy Alternative S4—Soil Vapor Extraction—removing VOCs from contaminated soils.

Soil Remedy Alternative S5—No Further Action

A discussion of each alternative is provided below.

Soil Remedy Alternative S1 – Exposure Controls

An exposure control approach is not intended to remove or destroy COCs in soils. Instead, it is intended to prevent current and future exposure pathways from becoming complete. Although the COCs would still be present, the public and site workers would not be exposed to harmful levels of these COCs. Exposure control would be achieved through a combination of engineering and institutional controls, as follows:

- A soil cover consisting primarily of asphalt pavement, which will be constructed across the Process Area. Following demolition of the above ground portions of site buildings and process units (see Section 7.0 of this FS), and the plugging of storm drains and other underground structures, the Process Area will be covered with a surface of asphalt pavement, including any needed base material. This pavement will be constructed in a manner that is suitable for normal commercial and industrial vehicle traffic, including semi-tractor trucks. The pavement will be continuous with foundations and related concrete structures that are left in place post-demolition. In addition, any significant breaches in the integrity of existing foundations, pads, or other concrete structures within the cover footprint will be repaired as a part of cover construction. The pavement and existing at-grade concrete structures together will comprise the soil cover in the Process Area. The anticipated footprint of this cover is shown on Figure 7.

- A soil cover consisting of geotextile overlain with approximately one foot of clean, low permeability soils, which will line the storm water collection ditch area on the southeast portion of the process areas (Figure 7). This geotextile/soil cover will be graded to maintain drainage to the south, and revegetated. Until revegetation is complete, the area will be monitored for excessive erosion, and repaired as needed.

- Institutional controls, including deed notices, ordinances, restrictive covenants, and other applicable measures, that would:

    - ◊ Provide information to potential future buyers of the Facility property of the presence and location of soil COCs.

    - ◊ Limit the use of the Facility property to commercial/industrial activities, and prohibit certain non-industrial commercial uses (e.g., health care or children’s day care) that would create an unacceptable risk scenario.

- ◊ Require the installation and maintenance of site control and security measures, such as fencing, to limit public access to the Facility property. These institutional controls would also limit activities that could disturb either the soils or the cover described above. Require the prompt and complete repair of any disturbance of the soil cover

- ◊ For any any activity that would involve soil disturbance, require:

  - — A characterization of the levels of COCs in soil or water that would be contacted during the disturbance activity.

  - — The utilization of personnel, equipment, and methods appropriate for work with soils containing those COCs.

  - — The management of soils, waters, or similar wastes generated from such activities in a manner that complied with state and federal regulations.

- ◊ Impose requirements for any new construction where there is the potential for unacceptable vapor intrusion risks. Within these areas, the design and construction of any new buildings or similar enclosed structures would have to include controls to limit the intrusion and accumulation of VOC vapors from underlying soils. The controls could include, but would not be limited to:

  - — An assessment of soil vapor levels at the specific location of the planned structure,

  - — The construction of passive venting systems for crawlspaces, the exclusion of basements, and/or

  - — The use of vapor barriers and VOC sensor/alarm systems.

As depicted in Figure 7, these institutional controls would be implemented across the entirety of the Facility property, with the exception of the wooded area west of the Wastewater Treatment Ponds.

Effectiveness of Exposure Controls

Once started, the engineering controls (soil cover and geotextile/soil cover) could be implemented using conventional construction techniques over an estimated period of three months. Construction of these controls cannot be started, however, until demolition of site structures is complete. It may be further delayed if remedy alternatives are selected that would include excavation or other disturbance of the areas planned for the soil cover and soil/geotextile cover. Since all of the institutional controls described above would affect on-property areas only, no negotiation or other interaction with other property owners would be required for their implementation. Given this, these institutional controls could presumably be rapidly put into place.

The primary purpose of these controls is to reduce the potential for direct contact to soils by workers and other potential receptors, and reducing the potential for vapor-intrusion exposures in future construction. Both engineering and institutional controls would become effective in controlling exposures immediately upon implementation, and would remain effective as long as they were maintained. They would therefore be effective over both the short and long term.

In addition to controlling direct contact and vapor intrusion risks, the engineering controls (soil cover and geotextile) would likely have the added benefits of:

- Improving storm water runoff quality, which would simplify the future management of storm water at the Facility.

- Reducing the infiltration of storm water through shallow soils, which would, in turn, reduce the flux of soil COCs to the Perched Zone and Alluvial Aquifer and help to reduce the concentrations of these COCs in groundwater.

In order to maintain the effectiveness of the engineering controls, regular inspections would be required, as well as avoiding activities that could damage the soil cover or geotextile, and repairing any such damage that may occur. The need to avoid damage to the soil cover would also potentially limit the types of construction activities that could occur in these areas of the site, and therefore preclude certain types of reuse.

Cost of Exposure Control

The cost to implement soil exposure control is approximately $3.0 Million. This includes costs for legal preparation and filings and related engineering work to implement institutional controls, which is assumed to be $25,000. Costs to maintain engineering controls were calculated to be $5,000 per year, although these costs will depend on many variables that are difficult to predict. At the conclusion of the remedy period, we assume that the soil cover and geotextile would be left in place; no decommissioning costs would therefore be required for these engineering controls. The removal of institutional controls would be largely a legal exercise, and is assumed to cost $15,000.

Please note that these costs do not include the demolition and removal of the aboveground portions of site structures, since these costs are addressed in another remedy element specific to demolition. They also do include any costs for long term groundwater monitoring, as these costs are addressed in remedy alternatives that describe monitored natural attenuation.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Soil Remedy Alternative S2 –*In Situ* Stabilization

The *in situ* stabilization (ISS) approach is not intended to remove or destroy COCs in soils, although some loss of VOCs from evaporation during soil mixing is a common ancillary effect of this remedy. Instead, ISS is intended to reduce the leachability and mobility of COCs in soil. With their mobility reduced, COCs are less likely to migrate from soils to groundwater, effectively reducing the source of groundwater impact. Stabilized soils also typically pose a lower risk than unstabilized soils with respect to both vapor intrusion and direct exposure.

ISS would require the removal of all surface improvements (including foundations), pavements, utilities, and other infrastructure in the areas to be treated. Once this removal is completed, soils would be excavated and mixed with a stabilizing material (the stabilant) using specially-equipped augers, trackhoes, or other equipment. This mixing would be performed primarily within the boundaries of the soil excavation. The stabilant may be fly ash, Portland cement, or another pozzolanic material. The preferred stabilant and mix ratios to meet remedial goals would be determined as a part of the Remedial Design process (see Section 10.0). Excavation and mixing would extend to approximately the top of the Perched Zone, at a typical depth of 17 feet.

At the conclusion of ISS, soils would be graded for desired drainage and remain in place within the excavation. Note that ISS often results in a slight volumetric increase in soil volume, so there may be a slight increase in the ground surface elevation within the ISS area.

At the Facility, ISS could be performed as either an area-wide or a focused approach. These differ as follows:

- Area-wide approach – This approach would address the entire Process Area portion of the Facility, as shown on Figure 8A.

- Focused approach – This approach would target specific areas ("hot spots") known to represent areas of waste disposal or elevated COCs, and stabilize those areas. For example, as shown on Figure 8B, ISS would target the Former Dinoseb Disposal Pond area. This approach would not attempt to address all areas of soil contamination at the Facility, but to immobilize a large fraction of the soil COCs through the stabilization of a geographically defined source area.

Effectiveness of *In Situ* Stabilization

ISS could be completed under an area-wide approach over a period of approximately 14 months, but could not commence until demolition and other remedy-related activities were completed across the Process Area. If the focused approach was utilized, the work area would be much smaller, and the timeframe would be much shorter—approximately 4 months.

Assuming the stabilant and mix ratios were effective in stabilizing the soils, this approach should reduce the leachability and mobility of soil COCs immediately upon completion. This effect should continue for several decades, depending on the stabilant used. ISS will likely not, however, result in an immediate reduction in groundwater COC levels. Such a reduction should occur, but may require a period of years to observe in the Perched Zone, and even longer in the Alluvial Aquifer.

Stabilized soils may pose less of a threat through direct exposure to future site workers and other receptors, since COCs are more firmly “bound” to the soil particles, and may therefore be less capable of migrating from the stabilized soils to receptors via skin absorption, dust generation, etc. This magnitude of this reduction is, however, difficult to predict until treatability tests are completed.

It should also be noted that ISS will not be effective in immobilizing or otherwise treating soil COCs outside the specific area where it is performed. There are localized areas, such as in the vicinity of the former laboratory (Figure 3) where elevated COCs are present. Under either the area-wide or focused “hot spot” approach, these localized areas would remain in place unchanged. Unless all of the areas exhibiting elevated soil COC levels at the Facility are stabilized, therefore, soil COCs will remain present as potential sources of groundwater contamination.

In summary, ISS would have both good short term and long term effectiveness in reducing the direct contact and vapor intrusion risks posed by soil COCs in the treatment area. It would have low short term effectiveness, but good long term effectiveness in improving groundwater quality at the site. This remedy will have to be maintained in perpetuity to continue to be effective. If the stabilant used begins to break down over time, therefore, it may be necessary to repeat the ISS process to maintain the effectiveness of the remedy.

Cost of *In Situ* Stabilization

The cost to perform ISS under the area-wide approach depicted on Figure 8A is approximately $8.7 Million, and under the focused “hot spot” approach depicted in Figure 8B is approximately $2.1 Million. Note that these costs do not include the costs of removing buildings and above-ground structures, since those demolition costs are addressed as a part of another remedy element (see Section 7.0 of this FS). These costs do include, however, the removal of slabs, pavement, and other at-grade and below-grade structures from the excavation footprint. There should be no on-going costs for operations and maintenance of the remedy, and no costs for decommissioning the remedy. Costs for a repeat of ISS, if necessary, are not included.

A breakdown of these implementation costs is provided in Appendix B.

Soil Remedy Alternative S3—Excavation with Off-Site Disposal as Solid Waste

Excavation with off-site disposal permanently removes soil COCs from the Facility, through bulk removal of contaminated soils and their permanent placement in an off-site disposal facility. Excavation with off-site disposal would require the removal of all surface improvements (including foundations), pavements, utilities, and other infrastructure. Once this removal is completed, soils would be excavated and segregated by waste classification (i.e., hazardous vs. non-hazardous). Hazardous and non-hazardous waste soils would remain segregated through the remainder of the remedy process. Soils would be transferred to container trucks and transported from the site to licensed hazardous and non-hazardous solid waste disposal facilities. Excavation would extend to approximately the top of the Perched Zone, at a typical depth of 17 feet.

Soils from the sidewalls of the resulting excavation would be analyzed at completion to confirm that cleanup objectives had been met, with additional excavation as necessary to address any locations identified to still have elevated COCs. As soil removal was completed, the excavation would be backfilled with clean fill. This fill would have to be purchased and imported from a local supplier, since there is no on-site source of backfill. Backfill would be graded for desired drainage.

Like ISS, excavation could be performed in either an area-wide or a focused “hot spot” approach. These differ as follows:

- Area-wide approach – This approach would address the entire Process Area portion of the Facility, as shown on Figure 9A.

- Focused approach – This approach would target specific areas (“hot spots”) known to represent areas of waste disposal or elevated COCs, and remove soils from those areas. For example, as shown on Figure 9B, excavation would target the Former Dinoseb Disposal Pond area. This approach would not attempt to address all areas of soil contamination at the Facility, but to remove a large fraction of the soil COCs through the excavation of a geographically defined source area.

Effectiveness of Excavation with Off-Site Disposal as Solid Waste

Excavation with off-site disposal could be completed under an area-wide approach over a period of approximately 14 months. If the focused “hot spot” approach was utilized, the work area would be much smaller, and the timeframe would be much shorter—approximately 4 months.

Because the soil COCs within the excavation area would be completely and permanently removed from the Facility, direct contact and vapor intrusion risks would be eliminated for soils within the excavation area. The removed soils would also no longer function as a source of groundwater contaminants. As with ISS, excavation will likely not, however, result in an immediate reduction in groundwater COC levels. It will likely require a period of years to observe water quality improvements in the Perched Zone, and potentially even longer in the Alluvial Aquifer.

It should also be noted that this approach will not mitigate the presence of soil COCs outside the specific excavation area. Unless all of the areas exhibiting elevated soil COC levels at the Facility are removed, therefore, soil COCs will remain present both as potential risk issues and as potential sources of groundwater contamination.

In summary, excavation with off-site disposal would have good short- and long-term effectiveness in reducing risk issues associated with direct soil contact, and good long-term effectiveness (but not short-term) in reducing groundwater COC levels.

Cost of Excavation with Off-Site Disposal as Solid Waste

The cost to perform excavation with off-site disposal under the area-wide approach depicted in Figure 9A is $50.0 Million, and under the focused “hot spot” approach depicted in Figure 9B is $11.9 Million. Note that these costs do not include the costs of removing buildings and above-ground structures, since those demolition costs are addressed elsewhere (see Section 7.0 of this FS). These excavation costs do include, however, the removal of slabs, pavement, and other at-grade and below-grade structures from the excavation footprint. There should be no on-going costs for operations and maintenance of the remedy, and no costs for decommissioning the remedy.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Soil Remedy Alternative S4—Soil Vapor Extraction

Soil vapor extraction, or SVE, utilizes wells or trenches to extract the air that fills much of the pore space in soils above the water table. As this air is withdrawn, vapor-phase COCs contained in the air are also removed. This removal will continue as evaporation of COCs in the subsurface transfers more chemical mass into the air being removed. SVE is most effective in relatively permeable material, and on volatile chemicals. Ancillary reductions of semi-volatile organics are sometime observed due to biologic action, however, in cases where SVE increases the oxygen content in soil gas.

The primary objective of SVE would be to improve groundwater quality by reducing the mass of VOCs that could ultimately reach Perched Zone and Alluvial Aquifer groundwater. SVE would also reduce vapor intrusion risks at the Facility, by reducing the mass of VOCs that behave as a source of organic vapors.

Given the primary objective cited above, SVE would be performed at locations with elevated VOCs either in soils or in the underlying Perched Zone groundwater (we are assuming that areas with elevated VOCs in Perched Zone groundwater are likely to be overlain by elevated VOCs in soils). The SVE system configuration under this area-wide approach is shown on Figure 10A. Alternatively, Figure 10B depicts how SVE could be focused on areas of elevated 1,2-DCA, in particular, rather than on volatile COCs in general. Under this focused approach, the SVE work would be concentrated in two areas based on Perched Zone groundwater levels of 1,2-DCA: at the former Unit 6, and at the former Unit 4 and 5 area.

Based on the shallow depth to water and high clay content of soils at this location, SVE will utilize a close extraction well spacing and relatively low vacuum pressures. For the purposes of this FS, a well spacing of approximately 20 feet and vacuums of approximately 40 inches of water are assumed. The extraction wells will be manifolded to the suction side of an extraction/treatment unit. Water condensing from the extracted vapor will be routed via a moisture knockout system to an aboveground tank. This water will be periodically collected for discharge to the Publicly Owned Treatment Works (POTW) intake at the Facility, subject to approval by the POTW operator.

Depending on the mass and character of VOCs removed and emitted to the atmosphere, it may be necessary to obtain an air emissions permit and/or perform emissions treatment in order to operate an SVE system. Emissions treatment options include activated carbon or thermal oxidation with scrubbing. The need for permitting and emissions treatment is more likely with larger systems (i.e., with the area-wide approach), since most emissions criteria are mass-based, with thresholds set in terms of tons of pollutant per year or pounds of pollutant per day.

The actual system specifications and operating parameters will be developed as a part of Remedial Design (discussed in Section 10.0). This will include any pilot testing and other activities needed to develop a final system design, as well as operating protocols.

Effectiveness of Soil Vapor Extraction

The short-term effectiveness of SVE as a remedy at the Facility will likely be poor, due to two factors:

- The Facility soils have a low permeability, so vapor removal from those soils will be slow. This means that the times required to achieve reductions in COC levels in soils and Perched Zone groundwater will be longer than those for a site with more permeable soils.

- SVE is primarily effective on volatile organics, and would not be expected to have any significant effect on the semivolatile or metal COCs present in soils and shallow groundwater.

Over the long-term, by contrast, SVE will likely have good effectiveness in reducing VOC levels in soils, which would be expected to result in a long-term reduction in levels of those COCs in underlying Perched Zone and Alluvial Aquifer groundwater. By reducing VOC mass, SVE will also be effective over the long-term in reducing the potential for vapor intrusion-based risks associated with Facility soils.

At this Facility, SVE would be difficult to implement on an area-wide basis (i.e., for all areas where elevated VOCs are observed). Under such an area-wide approach, as shown in Figure 10A, SVE would require an extremely large number of wells, with a correspondingly large and complex piping system to connect all those wells to the vacuum pumps. The result would be a widespread and complicated structure that would be difficult to maintain and repair.

In addition, the presence of these wells and piping would potentially interfere with other remedy activities, such as soil cover construction and building demolition. This could require that the implementation of an area-wide SVE system be delayed until after other remedy elements are completed. The SVE system would also significantly impede any reuse of the portion of the Facility being treated with SVE. All of these factors would be less of a concern for SVE implementation across a localized area, as in the focused approach shown in Figure 10B.

The installation of the SVE system for the area-wide approach would require approximately 9 months. Approximately 5 months would be required to construct the SVE system for the focused approach. Because SVE removes COCs from soils, the improvements observed by SVE would be permanent.

In summary, SVE used in a localized approach to treat specific VOC source areas would likely have good long-term effectiveness in reducing both soil and groundwater concentrations of those VOCs, and reducing vapor intrusion-related risks. An area-wide approach, in contrast, would be difficult to implement and maintain and would interfere with both site reuse and potentially other remedy activities. This approach is therefore considered to have poor effectiveness.

Cost of Soil Vapor Extraction

The cost to install an area-wide SVE system across all locations with elevated VOCs (see Figure 10A) is approximately $6.2 Million. This cost includes costs for permitting and for installation of an air emissions treatment. For treatment of the two elevated 1,2-DCA source areas at Unit 6 and Units 4/5, a more localized SVE system (see Figure 10B) would cost approximately $1.4 Million. Because this is a smaller system, these costs assume that emissions could be addressed without any exceptional permitting effort, and without emissions treatment.

Annual operations and maintenance costs are estimated to be approximately $1.4 Million for the area-wide approach, and approximately $517,000 for the focused approach that targets 1,2-DCA source areas. Decommissioning, including plugging and abandonment of all extraction wells, and removal of all piping and systems, would require approximately $951,000 for the area-wide approach, and approximately $375,000 for the 1,2-DCA source area approach.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Soil Remedy Alternative S5—No Further Action

Under a No Further Action (NFA) approach, no remedy would be implemented to address COCs in soils. Soils would be left in their existing condition, with no additional measures taken to reduce COC concentrations, and no controls implemented to limit potential public exposure to the soils, or to vapor intrusion risks associated with the soils.

Effectiveness of No Further Action

In their current condition, soils contain areas with levels of COCs that exceed criteria for safe exposure. In addition, soils are believed to be an on-going source of COC contribution to the underlying Perched Zone and Alluvial Aquifer groundwater. Finally, soils could be a source of vapor intrusion risks for future construction within portions of the Facility. In short, there are soil conditions at the Facility that should not be allowed to remain in an untreated or uncontrolled condition.

An NFA approach would have no short- or long-term effectiveness in addressing these conditions.

Cost of No Further Action

Because no action would be taken to address soil COCs or exposures, there would be no implementation, operations, or decommissioning costs associated with NFA.

6.2 PERCHED ZONE GROUNDWATER

The hydrogeologic characteristics of the Perched Zone are described in detail in Section 4.0 of the FI Report. In general, this zone is a low yielding, unconfined groundwater-bearing zone comprised of clays and silts extending from ground surface to approximately 30 to 40 feet bgs. The Perched Zone is not known to be used locally for water supply, and based on the extremely low hydraulic conductivities and corresponding low well yields observed in the Perched Zone, it is not realistic to expect that it would be so used in the future.

Based on groundwater samples collected both during the FI, and as discussed in Section 5.0 and Appendix A, only chloroform and 1,2-DCA are present in groundwater at concentrations above RBCs. The risk posed by these COCs is based on possible exposure via vapor intrusion, i.e. evaporation of volatile COCs from Perched Zone groundwater, and accumulation of the resulting vapors in indoor air space used by personnel. Figure 5 shows the locations where chloroform and 1,2-DCA are known to exceed screening criteria in Perched Zone groundwater.

The following remedy alternatives were evaluated for Perched Zone groundwater:

Perched Zone Groundwater Remedy Alternative P1—Exposure Control

Perched Zone Groundwater Remedy Alternative P2—Monitored Natural Attenuation

Perched Zone Groundwater Remedy Alternative P3—*In Situ* Chemical Oxidation

Perched Zone Groundwater Remedy Alternative P4—*In Situ* Enhanced Biodegradation

Perched Zone Groundwater Remedy Alternative P5—Hydraulic Control

Perched Zone Groundwater Remedy Alternative P6—Permeable Reactive Barriers

Perched Zone Groundwater Remedy Alternative P7—No Further Action

A discussion of each alternative is provided below.

Perched Zone Groundwater Remedy Alternative P1—Exposure Control

As discussed above, the exposure pathway of concern for Perched Zone COCs is via vapor intrusion. Vapor intrusion exposures can be controlled through various engineering and institutional controls, such that this pathway remains incomplete.

At the Facility, the primary area where COCs (1,2-DCA and chloroform) exceed vapor intrusion RBCs is throughout the northern Process Area (see Figure 5). In addition, a localized area to the west of the Process Areas also exhibits an RBC exceedance. In these areas, exposure control would consist of institutional controls. These would include deed notices, ordinances, restrictive covenants, and other applicable measures that would:

- Provide information to potential future buyers of the Facility property of the presence and location of Perched groundwater COCs.

- For any any activity that would involve disturbance of Perched Zone groundwater, require:

    - A characterization of the levels of COCs in soil or water that would be contacted during the disturbance activity.

    - The utilization of personnel, equipment, and methods appropriate for work with soils containing those COCs.

    - The management of soils, waters, or similar wastes generated from such activities in a manner that complied with state and federal regulations.

- Impose requirements for any new construction where there is the potential for unacceptable vapor intrusion risks. Within these areas, the design and construction of any new buildings or similar enclosed structures would have to include controls to limit the intrusion and accumulation of VOC vapors from underlying Perched Zone groundwater. The controls could include, but would not be limited to:

    - An assessment of soil vapor levels at the specific location of the planned structure,

    - The construction of passive venting systems for crawlspaces, the exclusion of basements, and/or

    - The use of vapor barriers and VOC sensor/alarm systems.

In addition, institutional controls would prohibit the production of Perched Zone groundwater for drinking water supply across the entire Facility property.

Effectiveness of Exposure Control

Since all of the institutional controls described above would affect on-property areas only, no negotiation or other interaction with other property owners would be required for their implementation. Given this, these institutional controls could presumably be put into place very rapidly. These institutional controls would become effective in controlling exposures immediately upon implementation, and would remain effective as long as they were in place. They would therefore be effective over both the short and long term.

Cost of Exposure Control

The cost to impose exposure controls to the pertinent portions of the Facility to address vapor intrusion risks from Perched Zone groundwater is $25,000. These costs primarily address legal filings and some technical support. This figure does not include the costs for engineering controls for vapor monitoring, exclusion, and removal within new buildings constructed in the control areas shown on Figure 5, since it is assumed that those costs will be incorporated into the building construction. No costs are included for the installation of engineering controls in existing buildings, since all existing buildings within the vapor intrusion risk areas will be demolished. Decommissioning, consisting of the removal of institutional controls, is also assumed to be $5,000.

Perched Zone Groundwater Remedy Alternative P2—Monitored Natural Attenuation

Monitored natural attenuation (MNA) allows natural processes, without human intervention, to reduce COC concentrations and/or mass. The natural processes involved may be physical, chemical, or biologic, and can include biodegradation, hydrolysis, dilution, sorption, and volatilization. As a part of this remedy alternative, groundwater is routinely monitored to confirm that these attenuation processes are continuing to be effective.

The monitoring network for MNA will utilize selected existing Perched Zone wells (including wells installed as a part of the FI) located in and near the areas where COC exceedances are observed. Analytes will consist of a target list of those COCs that exceed risk screening criteria. Monitoring data will be periodically evaluated to confirm that attenuation is occurring, with evidence of such attenuation including any or all of the following:

- A reduction in the area or footprint within which COCs exceed risk screening criteria.
- A reduction in the number of COCs present that exceed risk screening criteria.
- A reduction in the maximum or overall concentrations of COCs.

Monitoring data and their evaluation will be reported annually or biannually (depending on monitoring frequency) to ADEQ. If data trends over a sustained period do not support the conclusion that attenuation is occurring, then a re-evaluation of this remedy will be required. The wells to be utilized, monitoring parameters, monitoring schedule, evaluation methods, reporting schedule, timeframe, and potential trigger conditions for remedy re-evaluation will be developed and specified during the Remedial Design discussed in Section 10.0.

Effectiveness of Monitored Natural Attenuation

Although the data in hand suggest that attenuation may already be occurring within the Perched Zone, additional data acquisition from long-term monitoring will be required to confirm whether this process will be effective in meeting remedial objectives. MNA can be a lengthy process, with some recalcitrant chemicals (such as chlorinated hydrocarbons and pesticides) requiring years or even decades to decline below RBCs. While MNA may be effective over the long-term, because of the timeframes required, MNA will have little to no effectiveness over the short term.

It should also be noted that the long-term effectiveness of any remedy approach in the Perched Zone will depend upon the effectiveness of the remedy approach selected for the overlying soils. If the soil remedy or remedies selected do not reduce the mass and/or mobility of COCs, then those COCs will likely continue migrate downward to the Perched Zone. This could off-set or even negate any improvements in water quality observed as a result of MNA.

Cost of Monitored Natural Attenuation

Because MNA in the Perched Zone will utilize existing wells, there is no capital cost to implement this remedy. Annual operations and maintenance costs, consisting primarily of regular monitoring well sampling and reporting, are estimated to be $160,000. Decommissioning, including plugging and abandonment of all existing Perched Zone monitoring wells, is estimated to cost $168,000.

A breakdown of these annual and decommissioning costs is provided in Appendix B.

Perched Zone Groundwater Remedy Alternative P3—*In Situ* Chemical Oxidation

Chemical oxidation relies on the delivery of a powerful oxidant, such as hydrogen peroxide, sodium persulfate, or potassium permanganate, to chemically break down COC molecules. The oxidant is normally delivered by injecting a chemical solution into the subsurface via wells or trenches. Because oxidants will readily react with any material that can be oxidized, including organic matter and some minerals, they will be consumed and not persist for extended periods in soils and groundwater. The injection point must therefore be close enough to the targeted COCs for the oxidant to reach its destination before breaking down. In low transmissivity strata like the Perched Zone, this will require a very dense well spacing. In heterogeneous soils, this problem is exacerbated, since the oxidant solutions will tend to preferentially follow the more permeable strata within the water-bearing zone. Under these conditions, the oxidants may never reach COCs residing in less permeable strata.

The conceptual layout of the oxidant injection wellfield for the Facility is shown on Figure 11. Given the low transmissivity of the Perched Zone, a dense well spacing (25 ft grid) is assumed, with each well location representing a cluster of injection wells screened across multiple depths to achieve vertical coverage within the Perched Zone. It is also anticipated that multiple injection episodes will be required to achieve reasonable delivery of the oxidant to COC locations within the Perched Zone.

Effectiveness of *In Situ* Chemical Oxidation

It is estimated to require approximately 9 months to install the injection wellfield, piping, and injection facility shown on Figure 11. Once injection of oxidant commences, the large areas to be treated, the low hydraulic conductivity of the Perched Zone, and its heterogeneous nature will all be factors working against effective and complete oxidant delivery. Despite this, it is likely that a short-term reduction would be observed for COC concentrations in Perched Zone groundwater. This is a common result of chemical oxidation, as the COC mass in the more permeable and accessible portions of the water-bearing zone is broken down. If oxidant is not distributed throughout the less permeable portions of the Perched Zone, however, COC concentrations will gradually rebound once again to elevated concentrations.

Based on this analysis, *in situ* chemical oxidation is not considered to be a feasible alternative for the Perched Zone: the short-term effectiveness of *in situ* chemical oxidation may be good, but the long term effectiveness will likely be poor.

In addition, the presence of the extensive wellfield required (see Figure 11) would restrict the implementation of other remedy elements (e.g., the soil cover) within the chemical oxidation area until injection is completed. Given the need for a lengthy chemical oxidation injection period, this may mean lengthy delays in implementing other remedy elements.

Finally, it should be noted that the long-term effectiveness of any remedy approach in the Perched Zone will depend upon the effectiveness of the remedy approach selected for the overlying soils. If the soil remedy or remedies selected do not reduce the mass and/or mobility of COCs, then those COCs will likely continue migrate downward to the Perched Zone. This would reverse any short-term improvements observed from this or other Perched Zone remedy alternatives.

Cost of *In Situ* Chemical Oxidation

The cost to install the chemical oxidation injection system across all locations with elevated COCs (see Figure 11) is approximately $3.7 Million. This cost includes costs well, piping, and injection system installation. Operations and maintenance costs, including oxidant, are estimated to be $3.3 Million per year. Decommissioning, including plugging and abandonment of all injection wells, is estimated to cost approximately $1.6 Million. Note that this does not include the costs of on-going Perched Zone groundwater monitoring, as those costs are included in Remedy Alternative P2—Monitored Natural Attenuation.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Perched Zone Groundwater Remedy Alternative P4—*In Situ* Enhanced Biodegradation

In situ enhanced biodegradation would be performed by adding a source of carbon to the water-bearing zone; this carbon helps to stimulate biological conditions that degrade or consume COCs in the Perched Zone. One possible mechanism for this breakdown is for the carbon addition to stimulate the growth of methanogenic microbes. These generate methane as a waste byproduct, which in turn is consumed as a substrate (food source) by methanotrophic microbes. 1,2-DCA can be co-metabolized by these methanotrophs along with methane. Although 1,2-DCA has been shown to degrade under both anaerobic and aerobic conditions, we have assumed that anaerobic conditions would be most effective in accelerating 1,2-DCA degradation at the Facility.

As a part of the Remedial Design process (see Section 10.0), a treatability study would be performed to determine the most appropriate carbon source, carbon dosing, and delivery method. To achieve the desired conditions, carbon would be slowly amended into the groundwater via injection wells across the areas of COC exceedances (Figure 12). Unlike short-lived chemical oxidants, the geochemical changes derived from carbon amendment tend to be more persistent. The low permeability of the Perched Zone, however, will still impede effective oxidant delivery, and require the installation of a large number of injection well clusters. A well cluster spacing of 20 ft centers would be used for those areas where 1,2-DCA concentrations in groundwater exceed 10,000 micrograms per liter (µg/l), with a spacing on 40 to 50 ft centers for the remaining areas. Each well cluster would consist of three wells, screened so as to provide vertical coverage of the entire Perched Zone thickness. Carbohydrate will be injected in multiple episodes, allowing it to gradually disperse through the Perched Zone.

Effectiveness of *In Situ* Enhanced Biodegradation

As with chemical oxidation, the large areas to be treated, and the low hydraulic conductivity and heterogeneity of the Perched Zone will all be factors working against effective and complete carbohydrate delivery. There is also no certainty that the appropriate microbial populations are present to facilitate 1,2-DCA breakdown, or that they can be adequately stimulated by this approach. The persistence of carbohydrate amendment vs. chemical oxidants, however, suggest that it would be less likely to experience the rebound affect discussed for Remedy Alternative P2.

Installing the injection well system and performing the initial carbohydrate loading would require approximately 6 months. Once operational, and assuming that microbial populations respond to this method, enhanced biodegradation would likely reduce COC concentrations over both the short- and long-term. There is no certainty however, that they will reduce COC levels sufficiently to fall below applicable RBCs. Injection will probably need to continue for several years to ensure that carbohydrate is delivered to a sufficient volume of the Perched Zone.

In summary, while it is likely that *in situ* enhanced biodegradation will reduce concentrations of COCs, it may not be effective in either the short or long term in reducing them sufficiently to avoid some requirement for other remedy elements, such as exposure controls.

In addition, as with chemical oxidation, the presence of the extensive wellfield shown in Figure 12 would restrict the implementation of other remedy elements (e.g. soil cover) planned for the carbohydrate injection footprint. Given that the carbohydrate injection period is likely to be several years, this may substantially delay other parts of the remedy.

Finally, as discussed in the previous sections, the long-term effectiveness of any remedy approach in the Perched Zone will depend upon the effectiveness of the remedy approach selected for the overlying soils. If the soil remedy or remedies selected do not reduce the mass and/or mobility of COCs, then those COCs will likely continue migrate downward to the Perched Zone. This would reverse any short-term improvements observed from this or other Perched Zone remedy alternatives.

Cost of *In Situ* Enhanced Biodegradation

The cost to install the carbohydrate injection system across all locations with elevated COCs (see Figure 12) is approximately $3.2 Million. This cost includes well installation and the initial carbohydrate loading. Operations and maintenance costs are estimated to be approximately $1.8 Million per year, including the cost of periodic carbohydrate reinjections. Note that this does not include the costs of on-going Perched Zone groundwater monitoring, as those costs are included in Remedy Alternative P2—Monitored Natural Attenuation. Decommissioning, including plugging and abandonment of all injection wells, is estimated to cost approximately $1.7 Million.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Perched Zone Groundwater Remedy Alternative P5—Hydraulic Control

Hydraulic control in the Perched Zone would be intended to reduce the potential for elevated COCs to migrate laterally to new on- and off-site areas. In any water-bearing zone, hydraulic control is achieved by pumping groundwater via wells or trenches at a rate that exceeds the natural flow of groundwater.

With respect to the Perched Zone, the low transmissivity and relatively flat gradient indicate that existing groundwater velocities are relatively low. Individual pumping wells would likely have very small areas of influence in the low permeability Perched Zone soils. For this reason, French drain-type trenches, rather than wells, would likely be the most effective approach for groundwater pumping. These would be installed using a one-pass trenching operation to excavate to a depth of approximately 35 feet (roughly the base of the Perched Zone). In the same pass as excavation, the trenching equipment would simultaneously lay a flexible perforated pipe into the base of the trench and backfill the trench's lower portion with gravel or other permeable fill material. The flexible perforated pipe would be connected to a sump or well that can be pumped to remove water from the entire trench.

As shown on Figure 13, we expect that this approach would require the placement of two trenches: one along the southern edge of Process Units 1 through 5, and the other at Process Unit 6.

Water pumped from these trenches would contain COCs, so it would require treatment before being surface discharged. The degree of treatment would depend upon the discharge criteria stipulated in a permit obtained for this activity, and on the levels of COCs present in the pumped water. The details of the treatment approach would be developed as a part of the Remedial Design process discussed in Section 10.0. Given the nature of the COCs present, however, the treatment options would likely include air stripping with an activated carbon polish. If this treatment was utilized, air emissions from the stripper could be subject to the same requirements for permitting and treatment that are discussed under Soil Remedy Alternative S4 – Soil Vapor Extraction.

Installation of the hydraulic control system would require approximately one month, not including any time required for fabrication and delivery of the treatment system.

Effectiveness of Hydraulic Control

For organic COCs such as those present in the Perched Zone, it is generally accepted that groundwater pumping has relatively little effect on reducing contaminant mass or effecting long-term improvements in water quality. The primary purpose of a groundwater pumping approach at the Facility would therefore not be cleanup, but rather to reduce potential for COCs to migrate laterally.

Hydraulic control would be unnecessary (and therefore ineffective) to prevent COCs from migrating laterally to new areas, since the low transmissivity of the Perched Zone is already achieving this effect without human intervention. As described in the FI Report, Perched Zone groundwater impact is largely contained within the Facility boundaries, and is anticipated to remain there.

Hydraulic control would not substantially the downward migration of groundwater and COCs to the Alluvial Aquifer, would not eliminate the need for other Perched Zone groundwater remedies, such as Exposure Control, and would have no significant impact on vapor intrusion-based risks. Finally, to the extent that there were any positive effects of hydraulic control, they would only persist as long as the pumping was continued. At the conclusion of pumping, the COC concentrations in groundwater would gradually re-equilibrate with those in soils, returning to levels above RBCs.

In summary, hydraulic control is considered to have poor short- and long-term effectiveness for meeting remedial objectives with respect to Perched Zone groundwater.

Cost of Hydraulic Control

The cost to install the pumping system depicted in Figure 13 is estimated to be approximately $1.6 Million. This cost includes trenching, treatment system installation, permitting, and disposal of excess soils generated by excavation. Operations and maintenance costs are estimated to be approximately $166,000 per year. Note that this does not include the costs of on-going Perched Zone groundwater monitoring, as those costs are included in Remedy Alternative P2—Monitored Natural Attenuation. Decommissioning, including removal of shallow and surficial structures, is estimated to cost $367,000. This assumes that the trench would be left in place, with removal of the sumps and treatment plant.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Perched Zone Groundwater Remedy Alternative P6—Permeable Reactive Barriers

Permeable reactive barriers, or PRBs, rely on either natural or induced flow of groundwater through a vertical barrier. The barrier is constructed of a granular medium that reacts geochemically with the chemicals dissolved in groundwater to either destroy them or alter them to a less mobile or harmful form. Although various PRB media are in use today, metallic iron is one of the more common. The optimal medium for the Perched Zone would be selected through treatability testing as a part of the Remedial Design process (see Section 10.0). PRB may reduce, but not completely remove targeted COCs, and may not address all chemicals present in groundwater.

As with Hydraulic Control, the primary objective of a PRB-based remedy is COC migration control, rather than cleanup. A PRB can only address COCs in the groundwater that flows through the reactive medium, and would not affect COCs in relatively immobile source areas.

As discussed earlier, groundwater velocities in the Perched Zone are relatively low. In addition, as discussed in the FI Report (AMEC Geomatrix, February 2009), the groundwater gradient in this zone varies across the Facility, with a broad trough spanning much of the northern Process Area. Multiple PRBs would therefore be required to transect the areas of groundwater COC exceedance (see Figure 14). PRBs would be installed across most or all of the vertical extent of the Perched Zone, using either conventional or one-pass trenching techniques. Each PRB would include monitoring well clusters immediately up- and downgradient to measure the effect of the PRB on water quality.

One option would be to impose a desired gradient on the Perched Zone through installation of pumping centers. This would add significant complexity and cost to the PRB approach, and would be difficult to implement given the low transmissivity of this zone. For the purpose of this FS, therefore, pumping to induce a gradient or enhance the existing gradient was not considered as a part of this Remedy Alternative.

Effectiveness of Permeable Reactive Barriers

Permeable reactive barriers tend to be most useful in settings where groundwater is advectively transporting COCs to points of exposure. The PRB can then be placed to cut off that transport, and contain COCs within an area where the risk of exposure is lower. At the Facility, as discussed in the FI Report and under Remedy Alternative P5, there appears to be little to no lateral transport of COCs in Perched Zone groundwater, due to the low transmissivity of this zone. Without significant advective groundwater movement, PRBs would be largely ineffective in treating COCs. As with hydraulic control, PRBs appear to be largely unnecessary (and therefore ineffective) to prevent the lateral movement of Perched Zone

COCs, since natural conditions are already achieving this without any remedial action. As described in the FI Report, Perched Zone groundwater impact is largely contained within the Facility boundaries, and is anticipated to remain there.

Hydraulic control would not substantially the downward migration of groundwater and COCs to the Alluvial Aquifer, would not eliminate the need for other Perched Zone groundwater remedies, such as Exposure Control, and would have no significant impact on vapor intrusion-based risks..

Based on these factors, PRBs would not be an effective remedy alternative for the Facility over the short- or long-term, and would not meet remedial objectives.

Cost of Permeable Reactive Barriers

The cost to install the PRBs across into the Perched Zone (see Figure 14) is approximately $1.2 Million. This cost includes construction, barrier media, and wells to monitor PRB performance.

Operations and maintenance costs are estimated to be $74,000 per year. Note that this does not include the costs of on-going Perched Zone groundwater monitoring, other than the small number of wells installed in the immediate location of the PRBs. Costs for groundwater monitoring across the Perched Zone are included in Remedy Alternative P2—Monitored Natural Attenuation. Decommissioning, including plugging and abandonment of all PRB monitoring wells, is estimated to cost $209,000. This assumes that the PRB would be left in place, with only surface structures and the associated wells removed.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Perched Zone Groundwater Remedy Alternative P7—No Further Action

Under a No Further Action (NFA) approach, no remedy would be implemented to address COCs in Perched Zone groundwater. Groundwater would be left in its existing condition, with no additional measures taken to reduce COC concentrations, and no controls implemented to limit potential public exposure to vapors that could potentially emanate from groundwater.

Effectiveness of No Further Action

In their current condition, there are areas of Perched Zone groundwater within the Facility boudaries that contain with levels of COCs that exceed criteria for safe exposure. Although these COCs appear unlikely to move laterally to off-site areas, Perched Zone groundwater is believed to be an on-going source of COC contribution to the underlying Alluvial Aquifer groundwater. In short, there are groundwater conditions in the Perched Zone at the Facility that should not be allowed to remain in an untreated or uncontrolled condition.

NFA would have no short- or long-term effectiveness in addressing these conditions.

Cost of No Further Action

Because no action, including groundwater monitoring, would be taken to address Perched Zone COCs or exposures, there would be no implementation, operations, or decommissioning costs associated with an NFA approach.

6.3 ALLUVIAL AQUIFER GROUNDWATER

The hydrogeologic characteristics of the Alluvial Aquifer are described in detail in Section 4.0 of the FI Report. In general, this is a thick, highly transmissive and prolific sand and gravel aquifer which is locally used for agricultural and industrial supply. Although the Alluvial Aquifer is not currently used for domestic water supply in the vicinity of the Facility, there is currently no restriction against future use for this purpose. As discussed in Section 5.0 and Appendix A, assessment of risks posed by groundwater COCs in the Alluvial Aquifer therefore consider exposure related to ingestion.

The primary COC present in off-site Alluvial Aquifer groundwater is 1,2-DCA. Given its extent and the concentrations present, 1,2-DCA will likely be the primary COC driver for groundwater management decisions at the Facility, both on- and off-site, for the duration of the Alluvial Aquifer remedy performance. 1,2-DCA levels in excess of RBS are present in groundwater extending from the Facility to beyond the downgradient (southeast) boundary of the Industrial Park (Figure 6). An updated delineation of the boundary of this plume beyond the Industrial Park was not undertaken as a part of the FI because of litigation filed by the subject property owner.

As noted above, Alluvial Aquifer COCs are believed to derive from Perched Zone groundwater and COCs leaking to the deeper zone.

The following remedy alternatives were considered for Alluvial Aquifer groundwater:

Alluvial Aquifer Groundwater Remedy Alternative A1—Exposure Control

Alluvial Aquifer Groundwater Remedy Alternative A2—Monitored Natural Attenuation

Alluvial Aquifer Groundwater Remedy Alternative A3—*In Situ* Enhanced Biodegradation

Alluvial Aquifer Groundwater Remedy Alternative A4—Hydraulic Control

Alluvial Aquifer Groundwater Remedy Alternative A5—*In Situ* Chemical Oxidation

Alluvial Aquifer Groundwater Remedy Alternative A6—No Further Action

A discussion of each alternative is provided below.

Alluvial Aquifer Groundwater Remedy Alternative A1—Exposure Control

As discussed above, the exposure pathway of concern for Alluvial Aquifer COCs is via potential ingestion. The potential ingestion exposure pathway could be rendered incomplete by implementing institutional controls that prohibit the production of groundwater for domestic or drinking water supply within the COC exceedance area. Under such controls, wells producing water from the Alluvial Aquifer for these drinking water or domestic purposes could not be installed or operated within the controlled area.

Specifically, such institutional controls could include:

- Deed notices to inform any future buyers of the presence of COCs in Alluvial Aquifer groundwater on the subject property, as well as providing information regarding the limitations on use and related controls that would apply to that groundwater.

- Deed notices, ordinances, restrictive covenants, or similar restrictions, imposed on all on- and off-site areas where Alluvial Aquifer groundwater exceeds applicable risk thresholds for 1,2-DCA, in order to:

    - prohibit the use of Alluvial Aquifer groundwater for drinking water supply within the controlled areas.

    - Require any drilling to or through the Alluvial Aquifer within the controlled area to:

        - Utilize procedures, such as surface casings, that will minimize the transfer of COCs to deeper aquifers, and

        - Comply both with applicable health and safety regulations related to potential worker contact with COCs in groundwater and with waste management regulations.

Alluvial Aquifer institutional controls would be imposed across the area where 1,2-DCA exceeds 5 micrograms per liter (µg/l). As of September 2008, this area spanned much of the Facility and Industrial Park property, and extended an unknown distance under the property to the southeast of the Industrial Park.

Effectiveness of Exposure Control

As discussed in Section 5.0 and Appendix A, there are no current unacceptable exposures to COCs in Alluvial Aquifer groundwater, so the effectiveness of this and other remedy alternatives must be evaluated with respect to potential future exposures. Institutional controls could potentially be put into effect for on-property areas within weeks or a few months of proceeding. Under some circumstances, however, negotiations with landowners for voluntary consent to put controls in place on off-property areas, however, might add significant time to this implementation under some circumstances. Exposure controls that rely on such consent would not be effective until such negotiations could be completed, and this easily could require several months to a year. Imposition of such controls by ordinance, administrative order, or other legal mechanisms without landowner consent would likely also involve considerable delays. As noted above, however, there are no current unacceptable exposures to Alluvial Aquifer groundwater, so this time lag would not be likely to result in any unacceptable risks.

In summary, eliminating exposure routes using institutional controls would be effective over the long-term, and would be effective over the short term once any hurdles to their implementation were addressed.

Cost of Exposure Control

Imposing institutional controls across the areas discussed above would be largely a legal exercise, with some degree of technical support. Although the level of effort required for this is difficult to predict, it is assumed for the purposes of this FS that this will require $50,000. Decommissioning, consisting of the removal of institutional controls, is $5,000.

Alluvial Aquifer Groundwater Remedy Alternative A2—Monitored Natural Attenuation

Monitored natural attenuation (MNA), as discussed under Remedy Alternative P2, allows natural processes, without human intervention, to reduce COC concentrations and/or mass. These natural processes may be physical, chemical, or biologic, and can include biodegradation, hydrolysis, dilution, sorption, and volatilization.

The monitoring network will utilize selected existing wells (including wells installed as a part of the FI). These wells will be located within source areas, and downgradient from these areas to the downgradient terminus of the plume. Upgradient wells may also be utilized to provide data on background water quality. As a part of this implementation, access will be requested for the property downgradient of the Industrial Park for the installation of new wells to monitor the distal portion of the plume. Alternatively, wells may be placed at the nearest downgradient public right-of-way or easement to provide downgradient (sentry) monitoring. If delineation and monitoring at either location indicates that the 1,2-DCA plume is expanding, then the MNA remedy may be re-evaluated or modified to address specific areas of concern.

Monitoring data will be periodically evaluated to confirm that attenuation is occurring, with evidence of such attenuation including any or all of the following:

- A reduction in the area or footprint within which COCs exceed risk screening criteria.
- A reduction in the number of COCs present that exceed risk screening criteria.
- A reduction in the maximum or overall concentrations of COCs.

Monitoring data and their evaluation will be reported annually or biannually (depending on monitoring frequency) to ADEQ. If data trends over a sustained period do not support the conclusion that attenuation is occurring, then a re-evaluation of the MNA component of the remedy would be required. The wells to be utilized, monitoring parameters, monitoring schedule, evaluation methods, reporting schedule, timeframe, and potential trigger conditions for remedy re-evaluation will be developed and specified during the Remedial Design discussed in Section 10.0.

Effectiveness of Monitored Natural Attenuation

As discussed in the FI Report (AMEC Geomatrix, February 2009), the overall decline in the number and maximum concentrations of COCs suggest that natural attenuation processes have been occurring in the Alluvial Aquifer over the approximately 6 years between the termination of Facility operations and the collection of FI data. Even with these declines, however, concentrations of some COCs are still above RBCs.

MNA can be a lengthy process, with some recalcitrant chemicals (such as chlorinated hydrocarbons) requiring years or even decades to decline below RBCs. This suggests that MNA could be effective over the long-term, but that COCs in Alluvial Aquifer groundwater could remain above acceptable levels in some areas for 10 to 20 years, or even longer. As the plume shrinks, groundwater COC levels under off-property areas should drop below RBCs before those on-property. MNA may be most effective over the long-term on helping to restrict COC exceedances to on-property areas, than in eliminating groundwater COCs altogether.

In summary, MNA will likely be effective in reducing COC concentrations to below RBC levels, particularly in off-property areas, but only over the long term. Because of the timeframes required, it will have little effectiveness over the short term.

It should also be noted that the long-term effectiveness of any remedy approach in the Alluvial Aquifer will depend upon the effectiveness of the remedy approach selected for the overlying soils and Perched Zone. If the soil and Perched Zone remedy or remedies selected do not reduce the mass and/or mobility of COCs, then those COCs will likely continue migrate downward to the Alluvial Aquifer. This could off-set or even negate any improvements in water quality observed as a result of MNA.

Cost of Monitored Natural Attenuation

The cost to implement MNA for Alluvial Aquifer groundwater is $165,000. This cost includes the installation of new wells in off-property areas that are not currently monitored due to access restrictions, and an initial round of monitoring. Operations and maintenance costs, consisting primarily of regular sampling and reporting, are estimated to be $161,000 per year. Decommissioning, including plugging and abandonment of all Alluvial Aquifer monitoring wells, is estimated to cost $145,000.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Alluvial Aquifer Groundwater Remedy Alternative A3—*In Situ* Enhanced Biodegradation

In situ enhanced biodegradation would be performed by adding a source of carbon to the Alluvial Aquifer; this carbon helps to stimulate biological conditions that degrade or consume COCs. One possible mechanism for this breakdown is for carbon addition to stimulate the growth of methanogenic microbes. These generate methane as a waste byproduct, which in turn is consumed as a substrate (food source) by methanotrophic microbes. 1,2-DCA can be co-metabolized by these methanotrophs along with methane. Although 1,2-DCA has been shown to degrade under both anaerobic and aerobic conditions, we have assumed that anaerobic conditions would be most effective in accelerating 1,2-DCA degradation at the Facility..

As with Perched Zone enhanced biodegradation (see Remedy Alternative P3), carbon would be slowly amended into the Alluvial Aquifer groundwater via injection wells across the areas of COC exceedances (Figure 15). A well spacing of 20 ft centers would be used for those areas where 1,2-DCA concentrations in groundwater exceed 10,000 µg/l, with a wider spacing (40 to 50 ft centers) for the remaining areas. Carbohydrate will be injected in multiple episodes, allowing it to gradually disperse through the Alluvial Aquifer. As a part of the Remedial Design process (see Section 10.0), a treatability study would be performed to determine the most appropriate carbon source, carbon dosing, and delivery method.

Effectiveness of *In Situ* Enhanced Biodegradation

Installation of the injection well system will require approximately 6 months. Once installed, unlike the Perched Zone, the hydraulic conductivity of the Alluvial Aquifer suggests that carbohydrate delivery should be relatively straightforward. There is no certainty, however, that the appropriate microbial populations are present to facilitate 1,2-DCA breakdown, or that they can be adequately stimulated by this approach. Assuming that microbial populations respond as desired, injection would need to continue for several years to ensure that carbohydrate is delivered to a sufficient volume of the Perched Zone.

In summary, *in situ* enhanced biodegradation will likely be effective over the short- and long-term in reducing concentrations of COCs, but may not reduce them sufficiently to avoid requirements for other remedy elements, such as exposure controls. If used together with a remedy alternative such as MNA, *in situ* enhanced biodegradation could reduce the timeframe required by MNA to meet remedial objectives.

Finally, as discussed above, the long-term effectiveness of any remedy approach in the Alluvial Aquifer will depend upon the effectiveness of the remedy approach selected for the overlying soils and Perched Zone. If the soil and Perched Zone remedy or remedies do not reduce the mass and/or mobility of COCs, then those COCs will likely continue migrate downward to the Alluvial Aquifer. This could off-set or even negate any improvements in water quality observed as a result of enhanced biodegradation.

Cost of *In Situ* Enhanced Biodegradation

The cost to install the carbohydrate injection system across all locations with elevated COCs (see Figure 15) is approximately $1.2 Million. This cost includes well installation and the initial carbohydrate loading. Operations and maintenance costs are estimated to be approximately $909,000 per year, including the cost of periodic carbohydrate reinjections. Note that this does not include the costs of on-going Alluvial Aquifer groundwater monitoring, as those costs are included in Remedy Alternative A2—Monitored Natural Attenuation. Decommissioning, including plugging and abandonment of all injection wells, is estimated to cost approximately $947,000. This assumes that no aquifer restoration is required, post injection.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Alluvial Aquifer Groundwater Remedy Alternative A4—Hydraulic Control

Hydraulic control in the Alluvial Aquifer would be intended to limit the migration of COCs into off-site areas. As discussed in Remedy Alternative P4, hydraulic control in a water-bearing zone is achieved by pumping groundwater at a rate that exceeds the natural flow of groundwater. Although some portion of the COC mass is removed as a dissolved phase in the extracted groundwater, this removal is generally only an ancillary effect of pumping. In short, hydraulic control could potentially be used to limit the migration of groundwater COCs across the property boundaries, but would not actually achieve any significant cleanup of the groundwater.

With respect to the Alluvial Aquifer, the transmissivity, the likely yield of the aquifer and the area that would require control are likely to render a hydraulic control approach infeasible for the Alluvial Aquifer. It is not likely to be practicable to achieve complete hydraulic control of an aquifer so prolific across the 1,200 to 1,500 feet width of the 1,2-DCA plume. Any attempt at hydraulic control in the Alluvial Aquifer would require a large number of pumping wells, and would generate a very large volume of groundwater. All of the pumped groundwater would require treatment prior to surface discharge.

For the purposes of this FS, it is assumed that two fences of extraction wells, oriented generally north-south, would be constructed. One would be placed generally along the downgradient edge of the Facility property, and the second along the downgradient edge of the Industrial Park. The approximate locations of these extraction well fences are shown on Figure 16. In each well fence, extraction well clusters would be placed at an approximate spacing of 50 feet. Each cluster would consist of three extraction wells, completed in the upper, middle, and lower portions of the aquifer. This approach would require approximately 70 to 75 well clusters, or approximately 210 to 225 individual pumping wells.

Wells would be constructed with downhole electrical submersible pumps. Discharge from each well would be piped into a manifold that would deliver water to a central water treatment facility. This manifold would be set below grade for protection from freezing and mechanical damage.

Using hydraulic data from aquifer testing performed as a part of the Facility Investigation, the cumulative volume of water pumped by the two-fence system is estimated to be approximately 680 gallons per minute, or nearly one million gallons per day. Please note that this estimate is based on limited hydraulic data, and that the actual volume could potentially be much higher. Details of the system, including pumping rate and bulk water quality, would be more fully developed as a part of the Remedial Design process (see Section 10.0). This process should include the installation and testing of additional test wells along the planned extraction fence alignments.

Treatment of water containing elevated levels of 1,2-DCA could be performed in a number of ways, but for this FS we assume that water would be treated by air stripping followed by an activated carbon polish. Treated water would be discharged to a Facility outfall, under the terms of a National Pollutant Discharge Elimination System (NPDES) permit. Air emissions from the stripper would be treated using activated carbon adsorption, and are assumed to require a state or federal emissions permit.

Effectiveness of Hydraulic Control

A pumping system of the scale described in this remedial alternative, including the required treatment works, would require approximately one year to construct and become operational. Once operational, pumping would reduce, but not eliminate, the mass of COCs that is migrating from the Facility onto off-property areas. Given the scale of the plume and transmissivity of the Alluvial Aquifer, however, it is extremely unlikely that any pumping system could completely contain COC migration, i.e., that it could completely capture a plume of this size. Some mass of COCs would therefore continue to migrate across the Facility and Industrial Park boundaries to off-site properties.

If hydraulic control was successful in reducing the mass of COCs migrating across property boundaries, the COCs which are currently downgradient of those boundaries would begin to dissipate, as discussed under Monitored Natural Attenuation (Remedy Alternative A2). A period of at least several years, and, more likely, over a decade, would be required for COC levels in these off-site areas to fall below RBCs.

In addition, as discussed for hydraulic control in the Perched Zone (Remedy Alternative P5), this approach would not affect the sources of those COCs. If pumping was not maintained in perpertuity, then COCs would resume their migration across property boundaries.

In summary, hydraulic control of the Alluvial Aquifer would not likely be feasible at the Facility. Due to the lengthy period for construction/implementation, this approach would not be effective in controlling COC migration over the short term. Over the long-term, it could reduce, but not eliminate, COC migration across property boundaries. Hydraulic control would not effect the cleanup of the areas sourcing these COCs. COC levels could rebound in groundwater downgradient of the extraction well fences once pumping is terminated. Overall, hydraulic control is not considered to be an effective remedial alternative for meeting objectives for Alluvial Aquifer groundwater.

Cost of Hydraulic Control

The cost to install the pumping system depicted in Figure 16 is estimated to be approximately $8.0 Million. This cost includes well installation, piping, trenching, the required water and air emissions treatment, and permitting.

Operations and maintenance costs are estimated to be $810,000 per year, which includes groundwater testing, operation of the treatment works, and periodic re-development or replacement of extraction wells. This includes the periodic redevelopment and gradual replacement of pumping wells, with some need for well replacement. Note that this does not include the costs of on-going Alluvial Aquifer groundwater monitoring, as those costs are included in Remedy Alternative A2—Monitored Natural Attenuation. Decommissioning, including the plugging and abandonment of all wells, removal of piping, and demolition of the treatment plant, is estimated to cost $1.1 Million.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Alluvial Aquifer Groundwater Remedy Alternative A5—*In Situ* Chemical Oxidation

This approach is also discussed for the Perched Zone as Remedy Alternative P3. To implement *in situ* chemical oxidation, a powerful oxidant, such as hydrogen peroxide, sodium persulfate, or potassium permanganate, is delivered to throughout the targeted portion of the aquifer. This oxidant can chemically break down COC molecules. For the Alluvial Aquifer, this oxidant would be primarily intended to target 1,2-DCA.

Because oxidants will readily react with any material that can be oxidized, including organic matter and some minerals, they will not persist for extended periods in soils and groundwater. The injection well must therefore be close enough to the targeted COCs for the oxidant to reach its destination before breaking down. In the Alluvial Aquifer, the large volume of aquifer materials will limit the feasibility of oxidant distribution to all areas where COC exceedances are present.

The conceptual layout of the oxidant injection wellfield for the Facility is shown on Figure 17. Under this approach, oxidant would be injected throughout the on-property areas of the Alluvial Aquifer exhibiting the highest concentrations of 1,2-DCA. Repeated injections of oxidant would likely be required over time to deliver oxidant throughout the targeted portion of the Alluvial Aquifer. If chemical oxidation were to remove most or all of the COCs from these areas (which is not likely), the downgradient concentrations of COCs (primarily 1,2-DCA) would gradually decline through natural attenuation, although this decline would require years or even decades.

Effectiveness of *In Situ* Chemical Oxidation

In situ chemical oxidation could reduce the mass of COCs present in Alluvial Aquifer groundwater over the short term, as the reaction between COCs and oxidants is typically rapid. Once the oxidant had broken down, however, COC levels would likely rebound. This would occur because oxidant delivery tends to occur preferentially within the more conductive zones of any aquifer, and to leave residual COCs within less permeable zones. These untreated COCs can then gradually spread back through the aquifer after the oxidant has reacted away. Given the volume of Alluvial Aquifer materials to be treated at the Facility, even if treatment were focused solely on-site, the effective delivery and distribution of oxidant is not considered to be feasible. Even it this approach were feasible, its long term effectiveness would depend upon whether the sources of groundwater COCs were addressed through this remedy. If soil and Perched Zone remedy or remedies do not reduce the mass and/or mobility of COCs, then those COCs will likely continue migrate downward to the Alluvial Aquifer. This could off-set or even negate any improvements in water quality that chemical oxidation might cause.

Finally, the presence of the extensive wellfield shown in Figure 17 would restrict the implementation of other remedy elements (e.g. soil cover) planned for the same physical area. Given the time required for injection, the completion of these other remedy elements could be substantially delayed.

Overall, the use of *in situ* chemical oxidation is not likely to be an effective remedial alternative for the Alluvial Aquifer, over either the short- or long term.

Cost of *In Situ* Chemical Oxidation

The cost to install the chemical oxidation injection system across all locations with elevated COCs (see Figure 17) is approximately $8.0 Million. This cost includes the construction of injection and piping systems and the installation of injection wells. Operations and maintenance costs, including oxidant, are estimated to be approximately $3.5 Million per year. Note that this does not include the costs of on-going Alluvial Aquifer groundwater monitoring, as those costs are included in Remedy Alternative A2—Monitored Natural Attenuation. Decommissioning, including plugging and abandonment of all injection wells, and removal of the piping and injection systems, is estimated to cost approximately $1.6 million.

A breakdown of these implementation, annual, and decommissioning costs is provided in Appendix B.

Alluvial Aquifer Groundwater Remedy Alternative A6—No Further Action

Under a No Further Action (NFA) approach, no remedy would be implemented to address COCs in Alluvial Aquifer groundwater. Groundwater would be left in its existing condition, with no additional measures taken to reduce COC concentrations, and no controls implemented to limit potential ingestion or other domestic use of groundwater.

Effectiveness of No Further Action

Alluvial Aquifer groundwater currently exceeds ingestion criteria across an extended area. Groundwater within the known area of exceedance is not currently used for domestic purposes or ingested, so NFA would be effective in addressing current exposures, and therefore potentially effective over the short term. Without controls, however, NFA would not preclude the future use of groundwater containing elevated 1,2-DCA as a drinking water source. Given this potential for future exposure, NFA would not meet remedial objectives, and would therefore not be effective over the long term.

Cost of No Further Action

Because no action, including monitoring, would be taken to address Alluvial Aquifer COCs or exposures, there would be no implementation, operations, or decommissioning costs associated with a No Further Action approach.

6.4 REMEDY RECOMMENDATIONS

It is clear that no single remedy alternative will completely address potential exposures for the three media of concern at the Facility: unsaturated zone soils, Perched Zone groundwater, and Alluvial Aquifer groundwater. A combination of remedial approaches will be necessary to control exposures, reduce the areas affected by elevated COCs, and render the Facility suitable for re-use.

AMEC Geomatrix recommends that that following suite of remedy alternatives be selected by ADEQ for implementation at this site:

- Recommended Soil Remedy Elements
    - Exposure Controls—this would consist of the combination of engineering controls, including the soil cover and soil/geotextile cover, and institutional controls. The institutional controls would apply to the entire Facility property.
    - Soil Vapor Extraction, Focused Approach—as an active source removal effort, SVE would be implemented at the two areas overlying the highest 1,2-DCA concentrations in underlying groundwater.
    - *In Situ* Soil Stabilization—Focused Approach—as a second active source removal effort, ISS would be implemented across the area of the Former Dinoseb Disposal Ponds, to stabilize soils with elevated Dinoseb, 1,2-DCA, and other compounds.
- Recommended Perched Zone Groundwater Remedy
    - Exposure Controls—this would consist of institutional controls to mitigate the risk of vapor intrusion exposures in limited areas of the property. This would likely include the inclusion of vapor monitoring or control systems in any new building construction in those areas.
    - Monitored Natural Attenuation—If the two active soil remedy elements are successful, the COC levels in the Perched Zone will gradually decline. If this decline is not observed, however, it may be necessary to expand the scope of active remediation in the soils and Perched Zone groundwater.
- Recommended Alluvial Aquifer Groundwater Remedy
    - Exposure Controls—this would consist of institutional controls to preclude the use of Alluvial Aquifer groundwater for drinking water supply within the boundaries of the 1,2-DCA plume, including both on-site and off-site areas.
    - Monitored Natural Attenuation – some decline in COC levels has been observed over the time since Facility operations terminated in 2002. With the

active soil remedy elements described above, this trend is expected to continue.

As discussed in Sections 6.2, the hydraulic characteristics and extent of the Perched Zone are likely to frustrate both those approaches that rely on chemical delivery (i.e. chemical oxidation, *in situ* enhanced biodegradation) and those that rely on advective groundwater movement (i.e., hydraulic control). In the Alluvial Aquifer (see Section 6.3), the opposite is true—the large area involved and the prolific nature of the aquifer would render approaches such as chemical oxidation and hydraulic control infeasible.

Although cost was not utilized as a primary determinant in selecting approaches for recommendation, cost effectiveness was considered in the selection. Given the magnitude of the Facility and the costs involved, it would be undesirable for any party to invest extensive funding in an approach that is likely to prove ineffective or even infeasible.

The recommended suite of remedies is consistent with current EPA correction action approaches, and represents those technologies that are most likely to be effective under the conditions known to be present at the Facility. This approach would be likely to meet remedial objectives, and could be easily expanded, supplemented, or modified if new data identified exposures that were not being adequately controlled, or conditions that were changing in an unacceptable way.

6.5 SOIL AND GROUNDWATER REMEDY TERMINATION

The remedy selected will continue to be implemented until COC levels within the media (i.e., soil, Perched Zone groundwater, Alluvial Aquifer groundwater) governed by that control have declined below applicable risk thresholds. These thresholds may be risk screening criteria, or other criteria developed through either a supplemental risk assessment process or another appropriate process. On-going remedy elements such as MNA will continue until groundwater concentrations of COCs that exceed applicable risk thresholds are both stable in extent and limited to on-site areas, unless another endpoint is established that is protective of human health and the environment. At the conclusion of the remedy, Perched Zone and Alluvial Aquifer monitoring wells will be plugged and abandoned. The costs for this are included in the decommissioning costs for Perched Zone Groundwater Alternative P2 – Monitored Natural Attentuation, and Alluvial Aquifer Groundwater Remedy Alternative A2 – Monitored Natural Attentuation.

7.0 RECOMMENDATIONS FOR REMOVAL OF SITE STRUCTURES

With the exception of the Office buildings and the large Warehouse building (Figure 18) (requested by ADEQ to remain in place for potential future use), all aboveground portions of buildings, process units, tank systems, and related site structures at the Facility will be demolished or deconstructed. Unless their removal is required to implement a selected remedy element (for example, excavation or stabilization). slab foundations or similar at-grade and below-grade portions of these structures could remain in place to be incorporated into the soil cover system. In this event, the foundations and related structures should be inspected prior to their reuse. If any of these foundations or similar structures contain sumps, major failures, or other related breaches in their integrity, these will be permanently sealed as a part of the demolition/deconstruction process. In addition, storm grates, drains, and piping running beneath the demolition and soil cover area will be permanently plugged.

To the extent practicable, any portion of the structures that can be readily recycled will be salvaged. This stipulation applies primarily to the metal portions of the process units. Any non-salvaged materials will be managed as demolition debris. This management will include characterization and disposal at an appropriate off-site disposal facility, unless an acceptable alternative strategy is identified.

The estimated cost for implementation of this demolition/deconstruction is approximately $4.6 Million (Table 2). Details of this estimate are provided in Appendix C.

This Section does not apply to the Drum Vault and the Wastewater Treatment Ponds, which are discussed separately in Sections 8.0 and 9.0, respectively, of this FS.

8.0 RECOMMENDED REMEDY FOR DRUM VAULT

The Drum Vault is located in the central area of the Facility (Figure 2). Based on the FI evaluation, the Drum Vault contains both crushed drums and intact drums in poor condition, and approximately 4-6 feet of water-saturated sandy backfill. Although the contents of the drums were not identified, waste materials were visibly present in the drums. Analysis of the backfill and vault water identified several COCs at concentrations that exceeded a regulatory level.

Based on the presence of water contained in the Drum Vault at an elevation above the normal water table, the structure currently provides some degree of containment, limiting the release of COCs from within the Drum Vault. When the containment currently provided by the Drum Vault ultimately fails, however, it could result in a new release of COCs to the environment. This would reduce the effectiveness of on-going remedy efforts, and possibly result in an unacceptable exposure scenario. Given this, the recommended remedy for the Drum Vault is the removal of its contents for off-site disposal.

This remedy would consist of:

1. Demolition and removal of the above-grade portion of the overlying warehouse building.

2. Removal of the concrete slab (i.e., the warehouse floor slab) that covers the Drum Vault.

3. Dewatering of the Drum Vault backfill. All water will be stored and characterized for appropriate disposal. If its quality permits, it may be placed into the POTW inlet at the Facility, subject to the concurrence of the POTW operator.

4. Transferring the drums or drum portions and backfill in bulk from the Drum Vault to lined transport trucks. Based on the observed condition of the drums, individual drum removal is not anticipated to be feasible or necessary. If the Drum Vault contents are determined to be non-hazardous waste, they may be stabilized with flyash, Portland cement, or similar materials prior to removal.

5. Cleaning any residual drum, waste, or backfill material from the Drum Vault.

6. Backfilling the Drum Vault with clean, low permeability fill.

The removal of the Drum Vault is considered a final remedy with good long term effectiveness, and is protective of human health and the environment. The estimated cost for Drum Vault removal is approximately $743,000 (Table 2). Details of this estimate are provided in Appendix C.

The following alternative remedies were considered for the Drum Vault, but were not selected:

> No further action – This scenario would reduce remedy costs, but would leave a body of waste materials in place in a manner that could eventually result in a new release. This was considered an unacceptable remedy outcome that was inconsistent with remedy objectives.
>
> Waste stabilization – Under this approach, the drums, drum contents, and backfill would be mixed with a stabilizing material to reduce the mobility of COCs, as well as to reduce the presence of free water within the Drum Vault. This approach was considered less practicable than the bulk removal of the contents, because the heterogeneous nature of the materials would make selection of appropriate stabilizing agents and mixing of those agents difficult. On balance, given the characteristics of the vault as a defined and limited structure, and even though a stabilization approach could be less expensive, a removal-based approach was considered more practicable and permanent.

9.0 RECOMMENDED REMEDY FOR WASTEWATER TREATMENT PONDS

The current Wastewater Treatment Ponds (WWTP) are located south of Industrial Park Road (Figure 2). These ponds were constructed in 1977 and comprise the wastewater/storm water treatment system for the facility. The system consists of an API Separator, Flow Equalization Basin, Aeration Basin, two Clarifiers and a Polish Pond. Currently, these ponds receive storm water drainage from the entire facility. The effluent from the system is pumped 4.5 miles through an 8-inch line to a permitted outfall at the Mississippi River.

A characterization of the pond waters and sediments was not included in the FI scope—since these ponds continue to be used by ADEQ, any findings from such a characterization would have been subject to change based on future use. The FI did include, however, an evaluation of Perched Zone groundwater at the pond system. 1,2-DCA was present, but at concentrations much lower than those observed in the Perched Zone beneath process areas. Based on these data, the ponds are not considered a significant source of groundwater impact.

The recommended remedy for the WWTP is removal of the free liquids, removal or stabilization of the sediments/sludge, regrading of the pond area to shed storm water to appropriate drainage ditches, and revegetating the regraded surface. All ancillary structures, piping, and equipment will be decommissioned and removed, unless needed for future storm water management, treated groundwater discharge, or other use.

The decision on removal for off-site treatment and/or disposal vs. in place stabilization of the sediments/sludge will be made as a part of the Remedial Design process (Section 10.0). This decision will be based on physical and chemical characterization of the pond sediments at the time of pond closure, as well as any bench or pilot scale testing needed to finalize design decisions. Contingent upon characterization of pond waters at the time of closure, and with the approval of the POTW operator, these waters may be placed into the inlet of the local POTW.

The optimal timing for pond closure will depend upon the array of remedies selected for implementation at the Facility. Closure of these ponds should be performed at the conclusion of any actions taken to implement remedies, such as demolition/deconstruction, soil cover construction, and SVE system construction. While these activities are in progress, storm water from the site would continue to be managed in the WWTP.

The estimated cost for closure of the WWTP is approximately $964,000 (Table 2). Details of this estimate are provided in Appendix C.

The following alternative remedies were considered for the WWTP, but were not selected:

> No further action – This scenario would reduce remedy costs, but would leave in place pond waters and sediments that may contain COCs at unacceptable levels, and also could require continued, long-term management. This was considered an unacceptable remedy outcome that was inconsistent with remedy objectives.
>
> Continued use – Under this scenario, the WWTP would continue to be used for storm water management by future site users, for an undefined period of time. Future users, however, might decline to manage and use the WWTP. Therefore, this goal may not meet the remedy objective of achieving unmonitored discharge of storm water from the Facility.

10.0 REMEDIAL DESIGN WORKPLAN

This FS evaluates a number of remedy alternatives and recommends a suite of engineering and institutional controls that would cost-effectively meet the remedy objectives discussed in Section 4.0. The FS is not intended, however, to address all data needs associated with implementing the recommended remedies at the site. Particularly with respect to the engineering controls, additional work will be required to provide the level of detail required for such implementation. This additional work is considered to fall generally within the ambit of Remedial Design, and would include, but not be limited to, the following:

- Detailed description of site controls to be implemented during the various remedy activities.

- Identification of and compliance with requirements for regulatory permits and approvals.

- Installation of test wells and performance of aquifer testing to provide a more detailed hydraulic characterization of water-bearing zones.

- Bench scale and pilot scale testing to finalize the SVE system design, selection of stabilizing material and method, and other remedy activities.

- Description of any additional sampling, analysis, or monitoring of environmental media, including soil, groundwater, surface water, and air, required for remedy design or implementation.

- Final characterization of any wastes to be generated during the drum vault removal, soil stabilization, or other remedy activities, particularly with respect to hazardous vs. non-hazardous, as well as selection of a location and mode of disposition for those wastes.

- Preparation of engineering design and specification documents as needed to contract the construction, operation, maintenance, and/or performance of remedy elements.

- Identification of any requirements for public notice or interaction associated with remedy design or implementation.

- Possible performance of focused human health and/or ecological risk assessments to address specific COCs and their role in future remedy decisions.

- Specific design and implementation deliverables to be provided to the ADEQ, with an associated schedule.

The specific elements of the remedial design process will depend upon which remedy alternatives are selected for implementation by ADEQ. Once this selection is complete, therefore, it is recommended that a Remedial Design Workplan (RDWP) be developed to describe the performance of these remedial design elements. Depending on the outcome of pilot scale or bench scale testing, permitting, risk assessment, or other design-related factors, it may be necessary to modify the recommended remedies for the Facility, or to recommend different remedies entirely. Should this become necessary, the changes in recommended remedy elements, together with the basis for the change, will be submitted to ADEQ for their review and approval.

11.0 ESTIMATED REMEDY COSTS

Table 1 presents the estimated capital, annual operating, and decommissioning costs for the remedy alternatives evaluated in Section 6.0, with details of these estimates provided in Appendix B. Table 2 provides costs for the activities described in Sections 7.0, 8.0, and 9.0 (i.e., demolition, drum vault removal, and closure of the wastewater treatment ponds, respectively), with details of these estimates provided in Appendix C. Final project costs will vary from these cost estimates and will depend on actual labor and material costs, competitive market conditions, actual and unknown site conditions, final project scope, the implementation schedule, and other variables. A breakdown of the costs developed for specific remedy elements is included as Appendix B and C of this FS.

In particular, the following cost items could potentially have a major impact on the overall remedy costs, and represent significant uncertainty in the cost estimating process:

- Demolition/deconstruction costs and salvage value – The estimate for demolition was based on discussions with a single demolition contractor (other contractors were contacted but did not respond). Time constraints did not allow that contractor to actually visit the Facility, so the estimate they provided was based on their review of maps and aerial photographs. The actual demolition/deconstruction costs may vary considerably from this estimate. In addition, the salvage value of Facility metals and other materials can only be developed after the completion of extensive surveys and testing by salvage specialists. These efforts will be performed as part of the Remedial Design process described in Section 10.0 of this FS. A salvage value of 25 percent of the demolition/deconstruction cost was assumed for preliminary cost estimation purposes only. The actual salvage value may also vary considerably from this estimate.

- Waste characterization issues – with respect to the Drum Vault removal, WWTP closure, and other remedy elements, and based on the available sampling data, the remediation wastes that may be generated are assumed to be non-hazardous (Class 1 Industrial). Costs for waste management, permitting, and disposition would increase substantially if significant proportions of the waste are determined to be hazardous. Such a determination could require re-evaluation of remedy recommendations.

- The time required for remedy implementation. If remedy elements such as enhanced biodegradation, MNA, hydraulic control, or chemical oxidation are selected, these remedies may have an implementation lifespan of several years or even decades. Costs will continue to accrue as long as the remedy is on-going, so the ultimate duration will directly control the final cost of any remedy.

The estimated costs are intended to support comparison and preliminary evaluation of the various remedy alternatives, and are based on a conceptual scoping of the various remedy alternatives. They must be considered preliminary in nature, and subject to change.

TABLES

Table 1
Preliminary Estimate of Design and Implementation Costs for Remedy Alternatives
Cedar Chemical Corporation
Helena-West Helena, Arkansas

	Capital Cost	Annual Cost	Decommissioning Costs
Remedial Design/Workplan	$ 587,412		
Soil Remedy Alternatives			
Soil Remedy Alternative S1: Exposure Control	$ 3,009,573	$ 5,000	$ 15,000
Soil Remedy Alternative S2: In Situ Stabilization, Area-Wide Approach	$ 8,725,091		
Soil Remedy Alternative S2: In Situ Stabilization, Focused Approach	$ 2,144,255		
Soil Remedy Alternative S3: Excavation with Off-Site Disposal as Solid Waste, Area-Wide Approach	$ 50,034,669		
Soil Remedy Alternative S3: Excavation with Off-Site Disposal as Solid Waste, Focused Approach	$ 11,891,182		
Soil Remedy Alternative S4: Soil Vapor Extraction, Area-Wide Approach	$ 6,150,694	$ 1,412,553	$ 950,789
Soil Remedy Alternative S4: Soil Vapor Extraction, Focused Approach	$ 1,431,684	$ 516,715	$ 374,499
Soil Remedy Alternative S5: No Further Action			
Perched Zone Aquifer Remedy Alternatives			
Perched Zone Groundwater Remedy Alternative P1: Exposure Contol	$ 25,000		$ 5,000
Perched Zone Groundwater Remedy Alternative P2: Monitored Natural Attenuation		$ 159,509	$ 168,064
Perched Zone Groundwater Remedy Alternative P3: In Situ Chemical Oxidation	$ 3,673,685	$ 3,277,173	$ 1,559,330
Perched Zone Groundwater Remedy Alternative P4: In Situ Enhanced Biodegradation	$ 3,214,656	$ 1,777,030	$ 1,651,333
Perched Zone Groundwater Remedy Alternative P5: Hydraulic Control	$ 1,633,432	$ 166,150	$ 366,799
Perched Zone Groundwater Remedy Alternative P6: Permeable Reactive Barriers	$ 1,167,568	$ 73,952	$ 209,297
Perched Zone Groundwater Remedy Alternative P7: No Further Action			
Alluvial Aquifer Remedy Alternatives			
Alluvial Aquifer Groundwater Remedy Alternative A1: Exposure Controls	$ 50,000		$ 5,000
Alluvial Aquifer Groundwater Remedy Alternative A2: Monitored Natural Attenuation	$ 165,286	$ 161,383	$ 144,713
Alluvial Aquifer Groundwater Remedy Alternative A3: In Situ Enhanced Biodegradation	$ 1,183,260	$ 908,850	$ 946,519
Alluvial Aquifer Groundwater Remedy Alternative A4: Hydraulic Control	$ 8,048,186	$ 810,201	$ 1,136,388
Alluvial Aquifer Groundwater Remedy Alternative A5: In Situ Chemical Oxidation	$ 8,026,158	$ 3,493,653	$ 1,559,330
Alluvial Aquifer Groundwater Remedy A6: No Further Action			

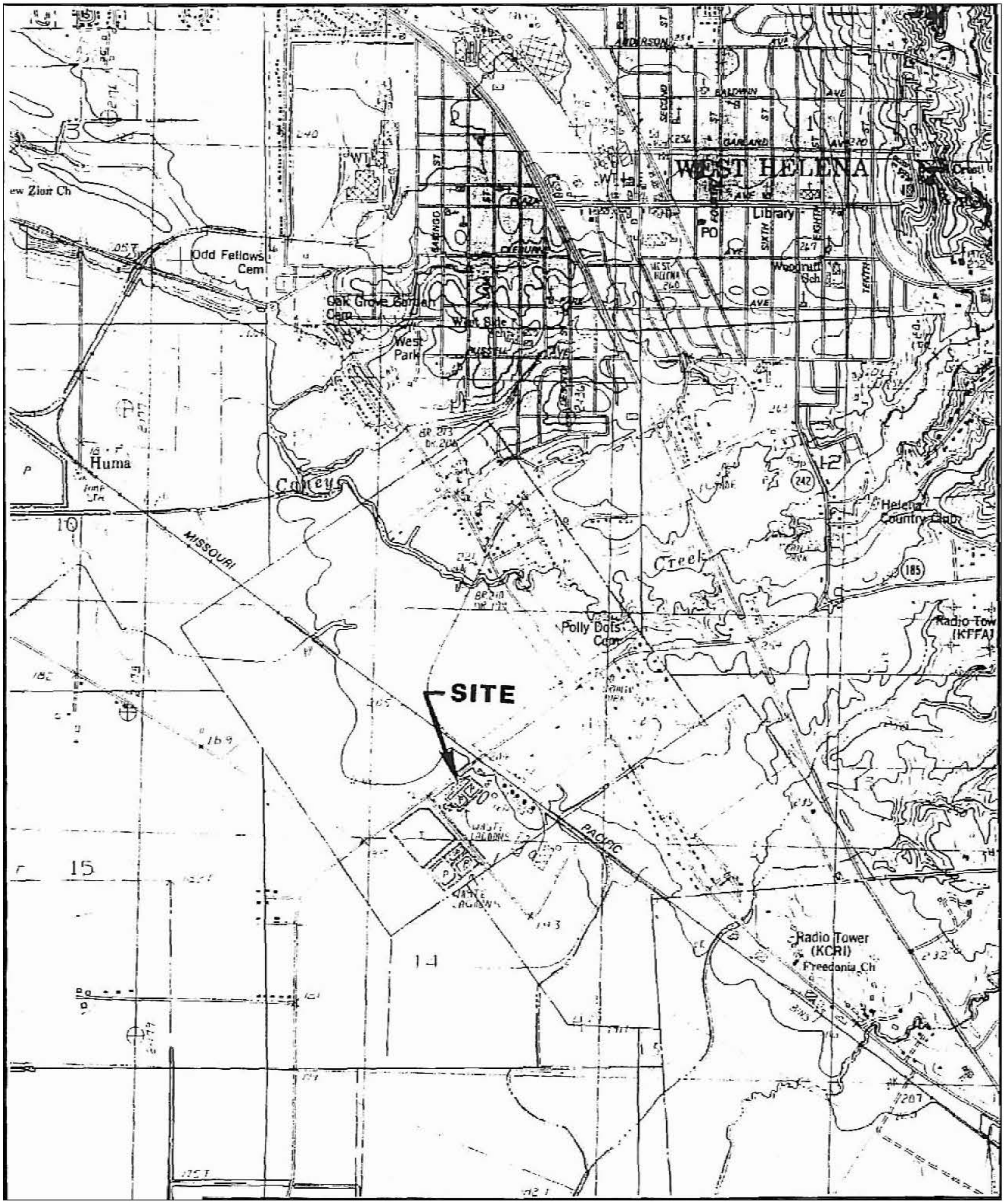
Notes:
1 Costs are preliminary estimates only, actual costs may vary based on remedial design, mode of implementation of the remedy, waste characterization, market costs at the time of implementation, or other factors.
2 Costs do not include legal expenses (other than routine administrative costs), payments to property owners, or other administrative costs.
3 Costs are in 2009 U.S. dollars, and are not adjusted for the future value of money, inflation, or similar factors.
4 Costs do not include storm water permitting or annual costs associated with storm water discharge, as it is assumed these will be borne by the site owner/operator.
5 Costs do not include any additional assessment, other than completion of delineation of 1,2-DCA to the southeast of the Industrial Park.
7 Costs may be lower than estimated if certain field tasks are combined.

Table 2
Preliminary Estimate of Design and Implementation Costs for Demolition and for Drum Vault and Wastewater Treatment Pond Closure
Cedar Chemical Corporation
Helena-West Helena, Arkansas

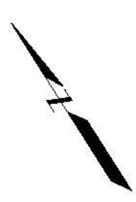
Activity	Estimated Cost	
Demolition	$	4,639,180
Drum Vault Closure	$	742,996
Future Wastewater Treatment Pond Closures (stabilization in place)	$	963,980
Totals	**$**	**6,346,156**

Notes:
1 Costs are preliminary estimates only. Actual costs may vary based on remedial design and mode of implementation of the remedy, waste characterization, market costs at the time of implementation, and other factors.
2 Costs do not include legal expenses or other administrative costs.
3 Costs are in 2009 U.S. dollars, and are not adjusted for the future value of money, inflation, or similar factors.
4 Costs may be lower than estimated if certain field tasks are combined.

Figures



SOURCE: EnSafe, Phase II Investigation Report, 1995



SITE LOCATION MAP

Cedar Chemical
Helena-West Helena, Arkansas

AMEC Geomatrix	Project 13636	Figure 1

I:\13636 - Arkansas Helena-West Helena\2007 CCR\FINAL FIGURES\ FIG 1 Site Location Map\FIG 1.dwg

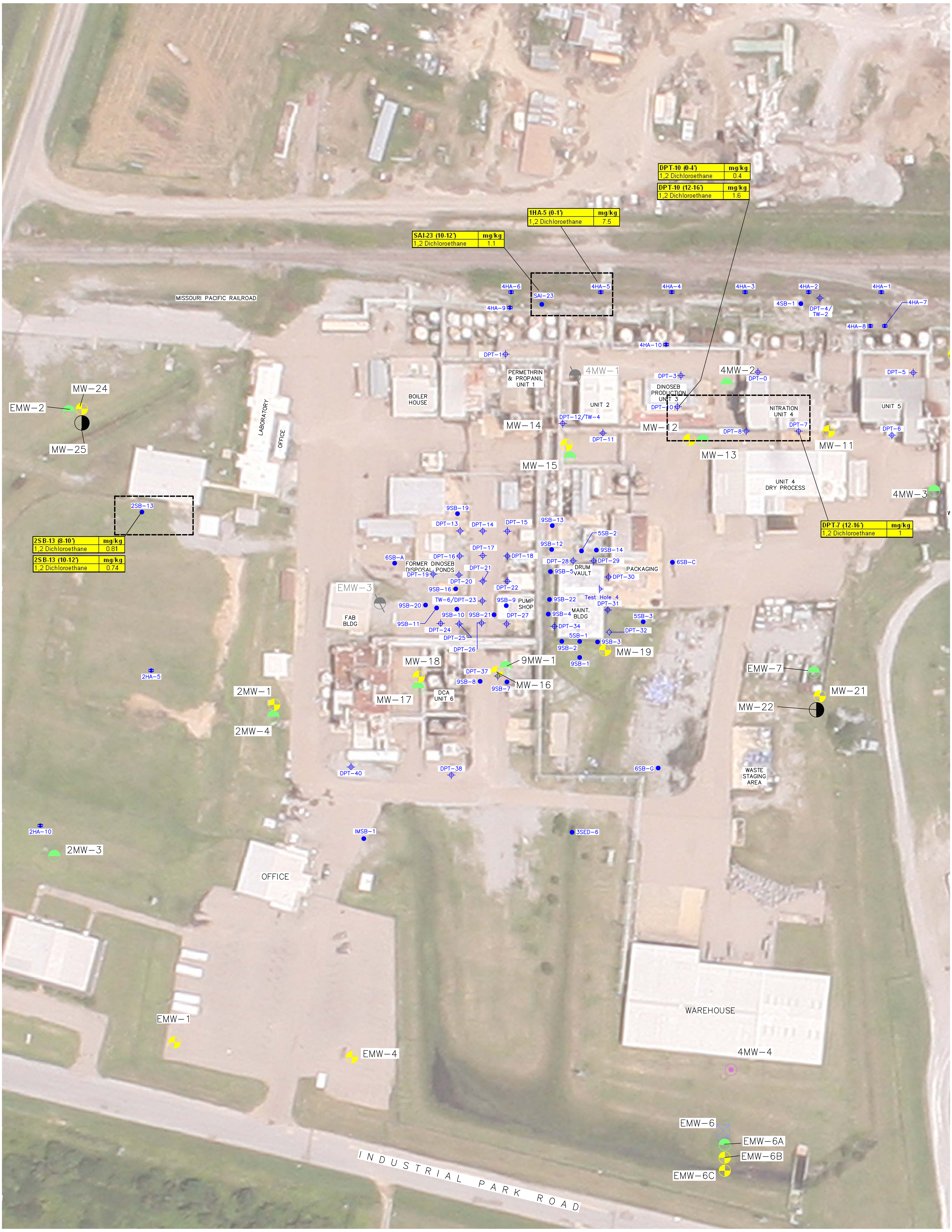
BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

0 80
APPROXIMATE SCALE IN FEET

Facility Structure Locations

Cedar Chemical
Helena-West Helena, Arkansas

By: MLS	Date: 7/25/09	Project No. 13636
AMEC Geomatrix		Figure 2



BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

Risk Screening Criteria:
All soil COCs were compared to USEPA 2007 Outdoor Worker Soil Vapor Intrusion screening levels. Risk Based Screening Levels were developed from this comparison.

COC	Vapor Intrustion Risk Based Screening Level (mg/kg)
1,2-Dichloroethane	0.354

EXPLANATION

COC — SAI-23 (10-12') mg/kg / 1,2 Dichloroethane 1.1 — Sample ID with Depth — Concentration of Analytes Detected Above RBSL

- Perched Zone Well Location
- Upper Alluvial Aquifer Well Location
- Middle Alluvial Aquifer Well Location
- Lower Alluvial Aquifer Well Location
- CMT Alluvial Aquifer Well with multiple completions (depths noted above)
- Plugged and Abandoned Well
- DPT Soil Sample Location
- Vapor Intrusion Exposure Controls Necessary

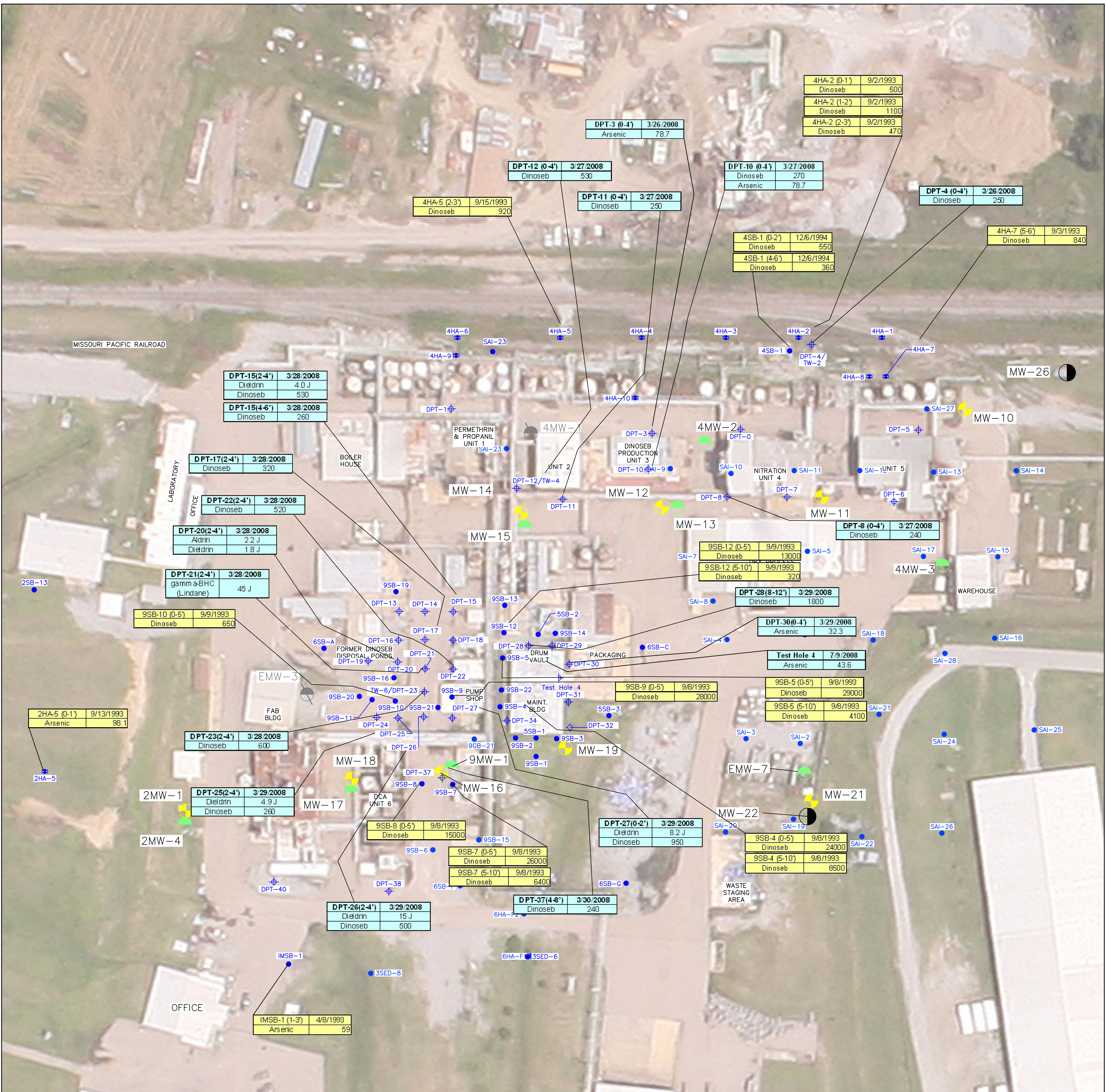
0 50
APPROXIMATE SCALE IN FEET

Constituents of Concern Above Vapor Intrusion-Based Risk Screening Levels in On-Site Soils

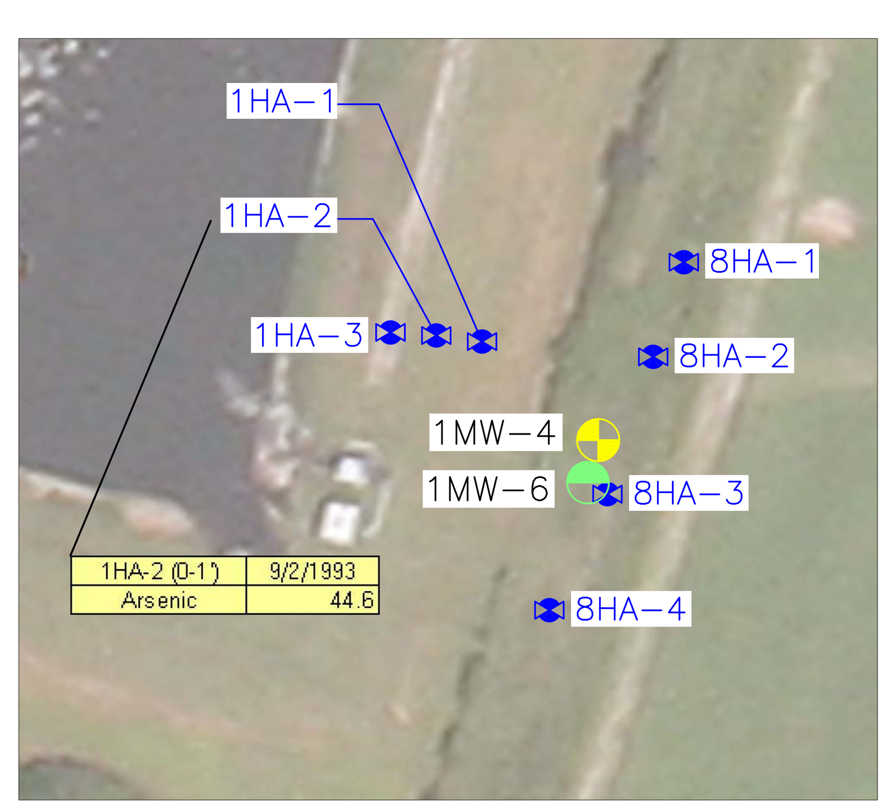
Cedar Chemical
Helena-West Helena, Arkansas

By: MLS | Date: 11/30/09 | Project No. 13636

AMEC Geomatrix | Figure 3



WASTEWATER TREATMENT POND AREA



Risk Screening Criteria:
All soil COCs were compared to USEPA 2007 Outdoor Worker Soil screening levels. Risk Based Screening Levels were developed from this comparison.

Analyte	Most Conservative Risk Based Screening Level (mg/kg)
Aldrin	1.01
Arsenic	16
Dieldrin	1.08
gamma-BHC (Lindane)	20.6
Dinoseb	238

Data from FI Report
Data from CCR Report

Sample ID with Depth — 9SB-12 (5-10') — Sample Date 9/9/1993 — Dinoseb 320 — Concentration of Analytes Detected Above RBSL

All soil analytical results shown are in milligrams per kilogram (mg/kg).

J Estimated concentration for analyte.

0 50 APPROXIMATE SCALE IN FEET

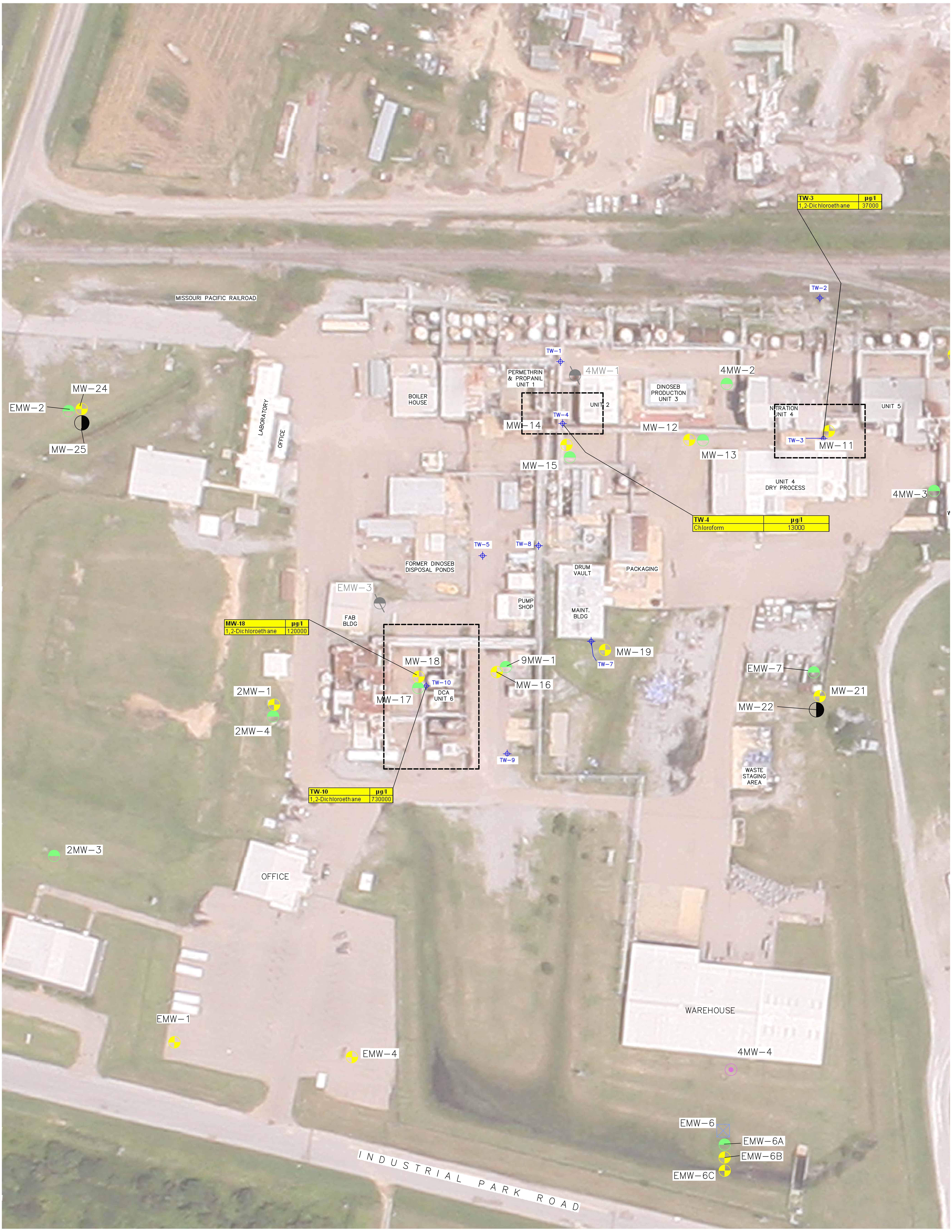
Perched Zone Well Location
Upper Alluvial Aquifer Well Location
Middle Alluvial Aquifer Well Location
Lower Alluvial Aquifer Well Location
CMT Alluvial Aquifer Well with multiple completions (depths noted above)
Plugged and Abandoned Well
DPT Soil Sample Location

Constituents of Concern Above Direct Contact-Based Risk Screening Levels in On-Site Soils

Cedar Chemical
Helena-West Helena, Arkansas

By: MLS	Date: 12/8/09	Project No. 13636

AMEC Geomatrix — Figure 4



BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

EXPLANATION

Risk Screening Criteria:
All groundwater COCs were compared to USEPA 2007 groundwater screening levels. Risk Based Screening Levels were developed from this comparison.

COC	Vapor Intrusion Risk Based Screening Level (µg/l)
1,2-Dichloroethane	14840
Chloroform	8940

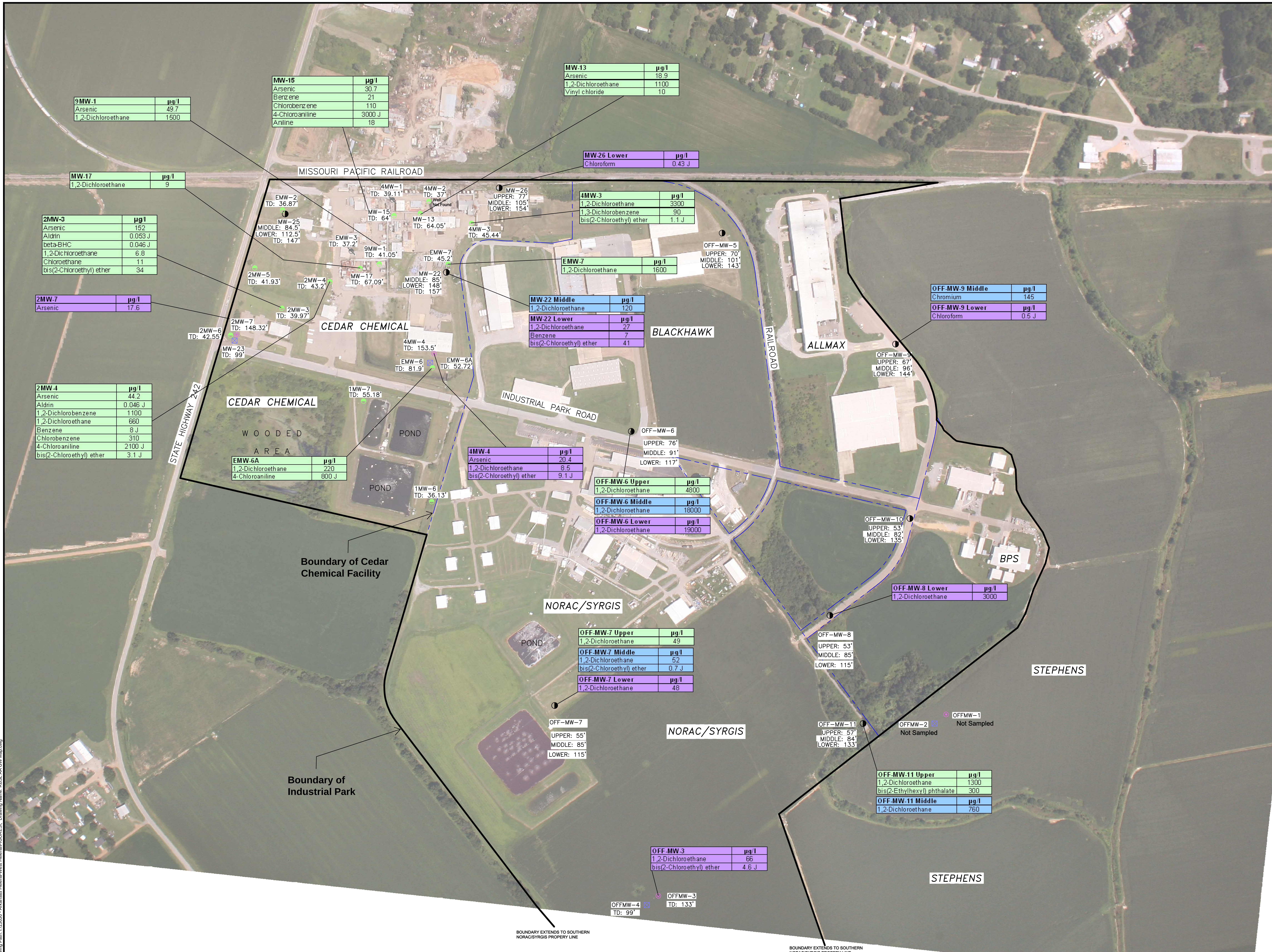
- **Perched Zone Well Location**
- **Upper Alluvial Aquifer Well Location**
- **Middle Alluvial Aquifer Well Location**
- **Lower Alluvial Aquifer Well Location**
- **CMT Alluvial Aquifer Well with multiple completions (depths noted above)**
- **Plugged and Abandoned Well**
- DPT Temporary Well Groundwater Sample Location
- Vapor Intrusion Exposure Controls Necessary.
- µg/l micrograms per liter

0 80
APPROXIMATE SCALE IN FEET

Constituents of Concern Above Vapor Intrusion-Based Risk Screening Levels in Perched Zone Groundwater

Cedar Chemical
Helena-West Helena, Arkansas

By: MLS	Date: 7/25/09	Project No. 13636
AMEC Geomatrix		Figure 5



EXPLANATION

- Upper Alluvial Well Location
- Middle Alluvial Well Location
- Lower Alluvial Well Location
- CMT Alluvial Well with multiple completions (screen depths noted)
- Plugged and Abandoned Well

- Upper Alluvial Aquifer
- Middle Alluvial Aquifer
- Lower Alluvial Aquifer

Concentrations reported are from the most recent sampling event (Fall 2008).

Risk Screening Criteria:
All groundwater COCs were compared to higher of applicable USEPA 2007 Tapwater Media Specific Screening Level and MCL.

COC	Higher of MCL/Tap Water Screening Level* (µg/l)
1,2-Dichlorobenzene	600
1,2-Dichloroethane	5
1,3-Dichlorobenzene	15
4-Chloroaniline	150
Aldrin	0.004
Aniline	12
Arsenic	10
Benzene	5
beta-BHC	0.037
bis(2-Chloroethyl) ether	0.0098
bis(2-Ethylhexyl) phthalate	6
Chlorobenzene	100
Chloroethane	3.9
Chloroform	0.17
Chromium	100
Vinyl chloride	2

* 2007 USEPA Screening Table

0 125 250
Approximate Scale in Feet

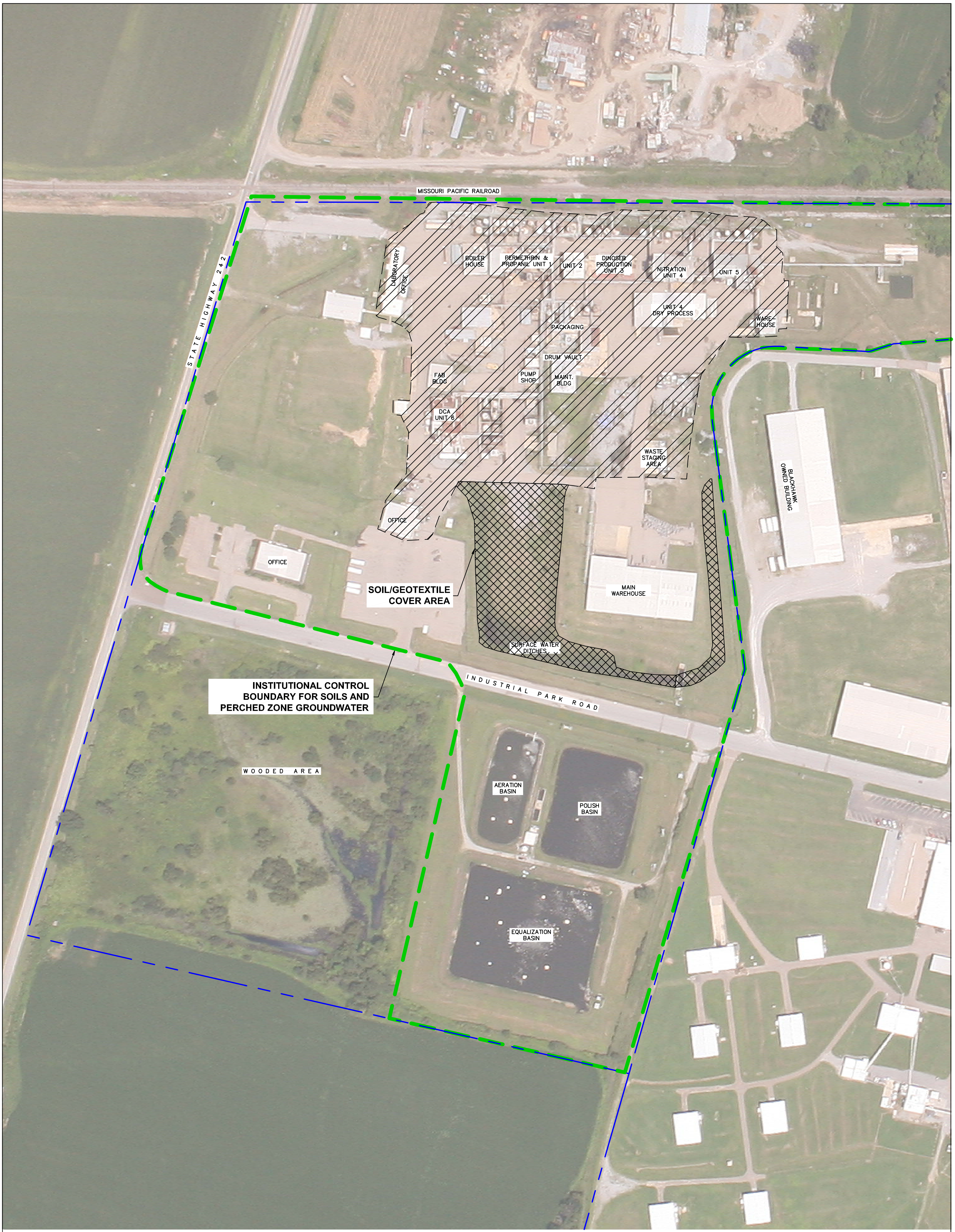
Constituents of Concern Above Ingestion-Based Risk Screening Levels in Alluvial Aquifer Groundwater

Cedar Chemical
Helena-West Helena, Arkansas

By: MLS | Date: 12/8/09 | Project No. 13636.000

AMEC Geomatrix — Figure 6

2/10/09 RBSL AA GW Map.dwg



EXPLANATION

SOIL COVER

SOIL / GEOTEXTILE COVER AREA

WASTEWATER TREATMENT POND CLOSURE AREA

INSTITUTIONAL CONTROL

PROPERTY BOUNDARY

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

SOIL REMEDY ALTERNATIVE S1
Exposure Control
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL | Date: 12/10/09 | Project No. 13636.000

AMEC Geomatrix

Figure 7

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

EXPLANATION

SOIL STABILIZATION AREA

PROPERTY BOUNDARY

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

SOIL REMEDY ALTERNATIVE S2
In Situ Stabilization
Area-Wide Approach
Cedar Chemical
Helena-West Helena, Arkansas

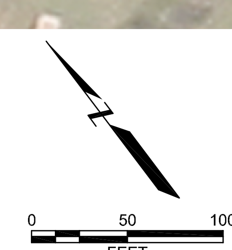
By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 8A

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

EXPLANATION

SOIL STABILIZATION AREA

PROPERTY BOUNDARY



BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

SOIL REMEDY ALTERNATIVE S2 In Situ Stabilization Focused Approach Cedar Chemical Helena-West Helena, Arkansas		
By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 8B

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

EXPLANATION

SOIL EXCAVATION AREA

PROPERTY BOUNDARY

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

SOIL REMEDY ALTERNATIVE S3
Excavation with Off-Site Disposal as Solid Waste
Area-Wide Approach
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 9A

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

EXPLANATION

SITE EXCAVATION AREA

PROPERTY BOUNDARY

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

SOIL REMEDY ALTERNATIVE S3
Excavation with Off-Site Disposal as Solid Waste
Focused Approach
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 9B

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

EXPLANATION

PIPING

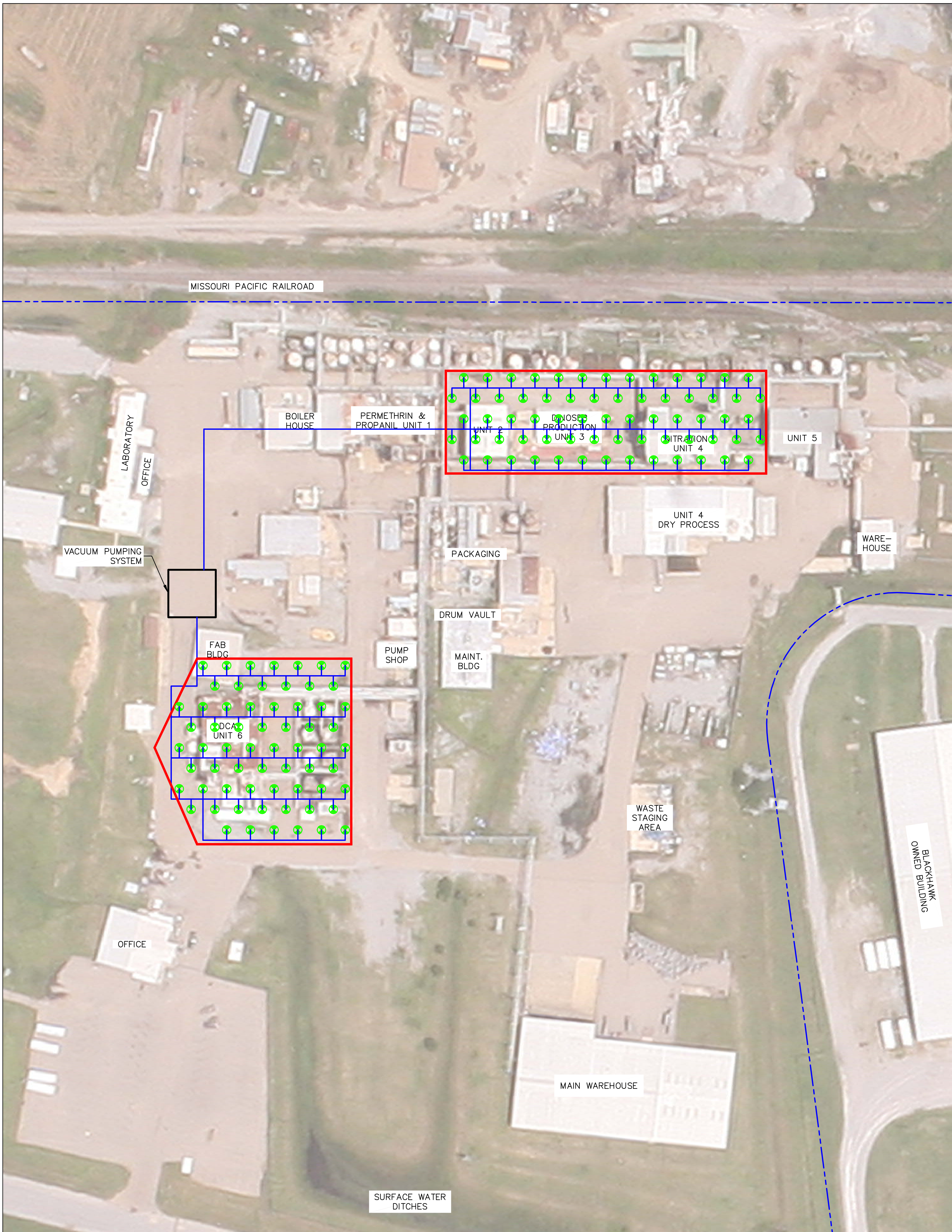
SOIL VAPOR EXTRACTION WELL

PROPERTY BOUNDARY

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

SOIL REMEDY ALTERNATIVE S4 Soil Vapor Extraction Area-Wide Approach Cedar Chemical Helena-West Helena, Arkansas		
By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 10A

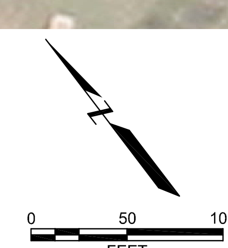


EXPLANATION

PROPERTY BOUNDARY

PIPING

SOIL VAPOR EXTRACTION WELL

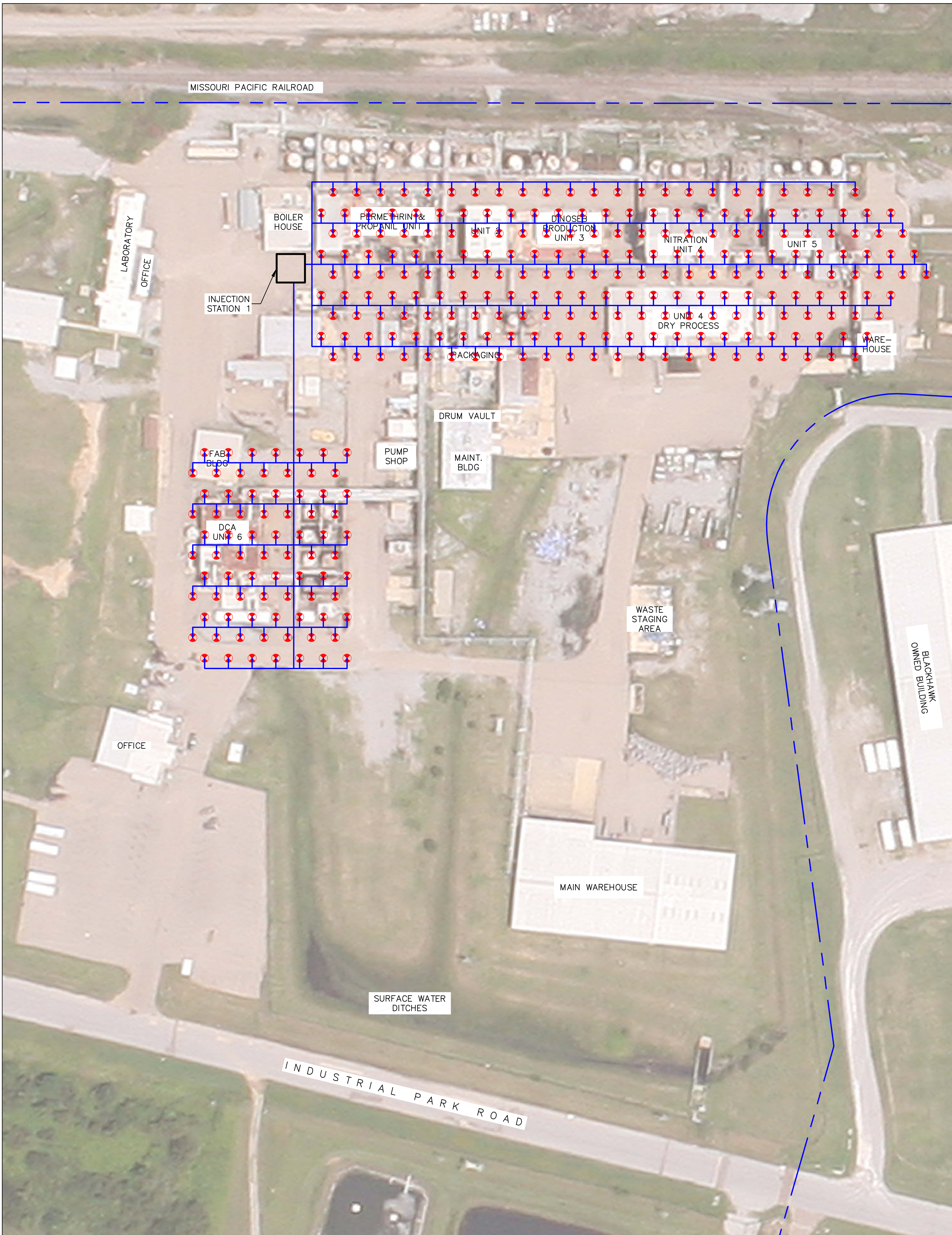


BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

SOIL REMEDY ALTERNATIVE S4
Soil Vapor Extraction
Focused Approach
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 10B

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.



EXPLANATION

INJECTION WELL CLUSTER (3 WELLS PER CLUSTER)

PIPING

PROPERTY BOUNDARY

0 50 100
FEET

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

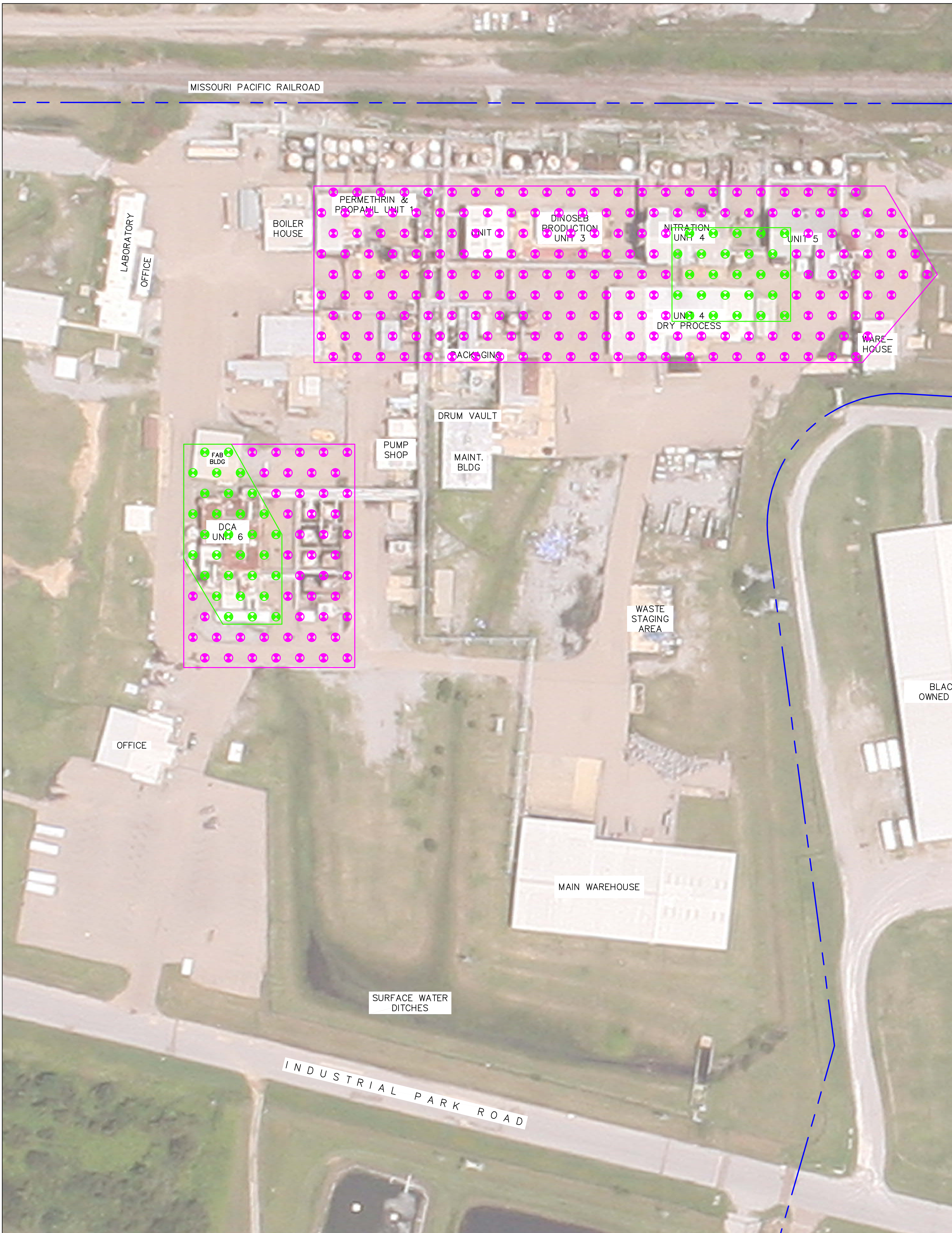
PERCHED ZONE GROUNDWATER
REMEDY ALTERNATIVE P3
In Situ Chemical Oxidation
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000

AMEC Geomatrix

Figure 11

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.



EXPLANATION

INJECTION WELLS AT 20' SPACING

INJECTION WELLS AT 40' - 50' SPACING

PROPERTY BOUNDARY

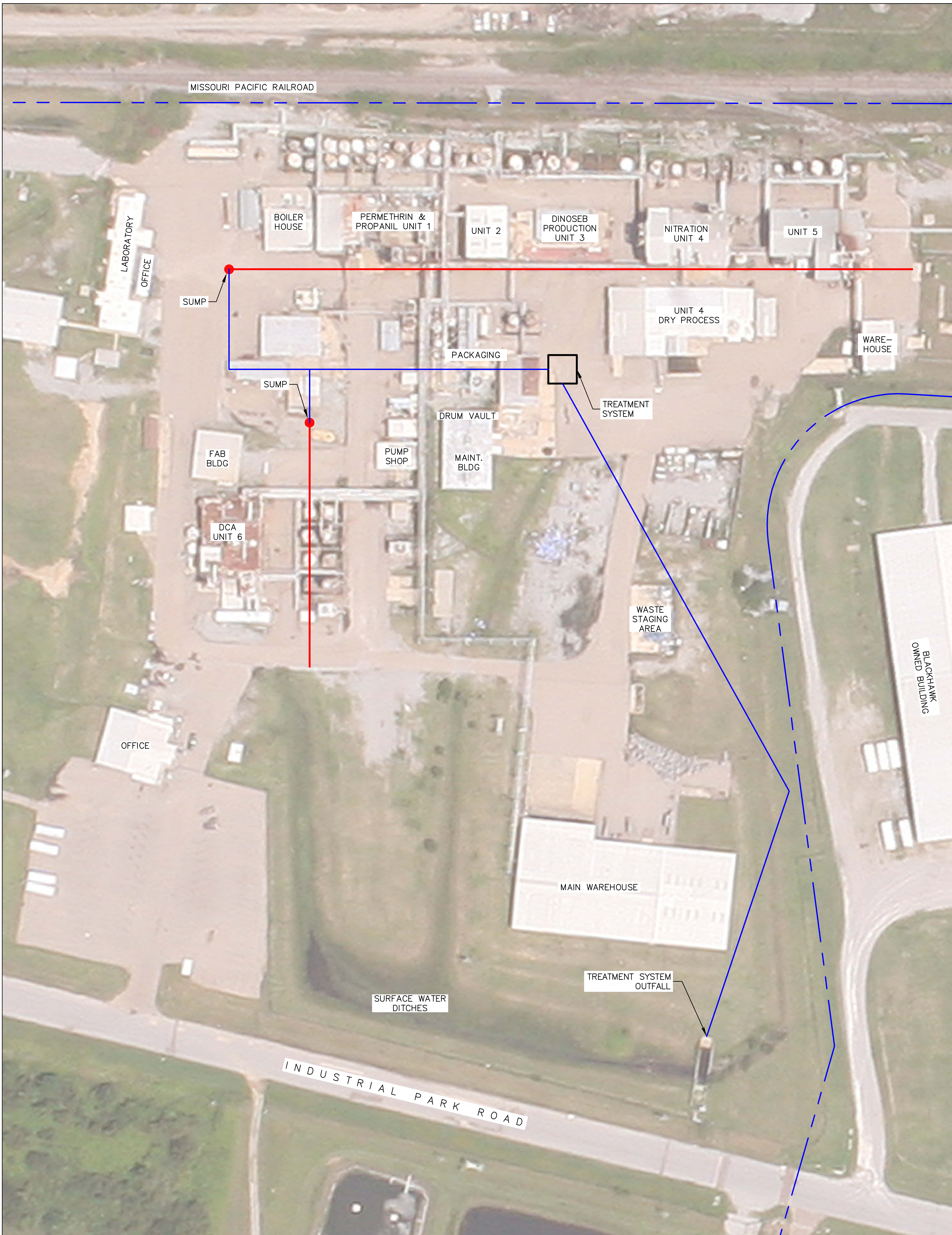
0 50 100
FEET

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

PERCHED ZONE GROUNDWATER
REMEDY ALTERNATIVE P4
In Situ Enhanced Biodegradation
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 12



EXPLANATION

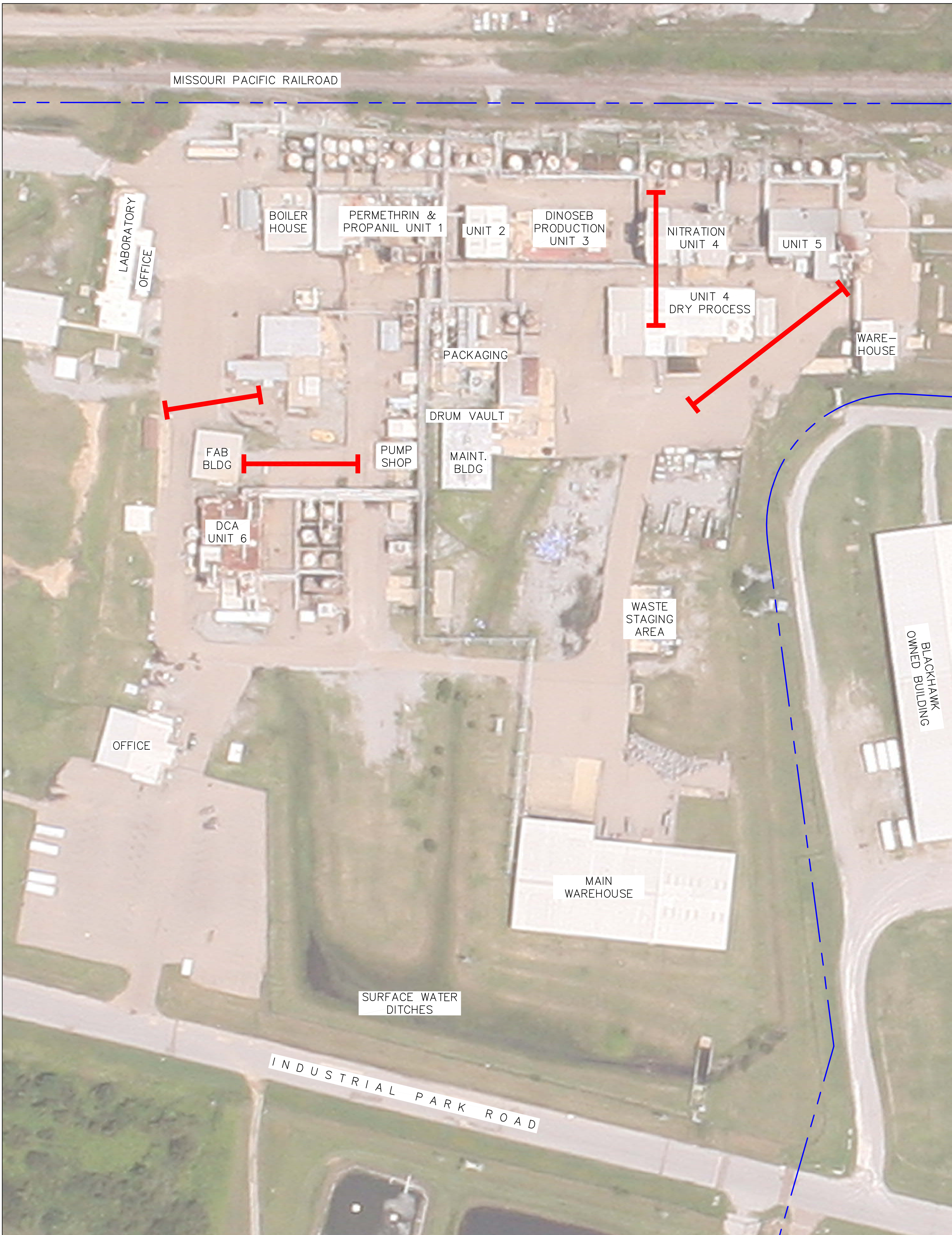
- PROPERTY BOUNDARY
- PUMPING TRENCH
- PIPING
- SUMP

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

PERCHED ZONE GROUNDWATER
REMEDY ALTERNATIVE P5
Hydraulic Control
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 13

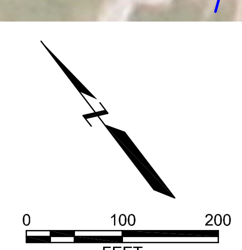
NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.



EXPLANATION

PERMEABLE REACTIVE BARRIER

PROPERTY BOUNDARY

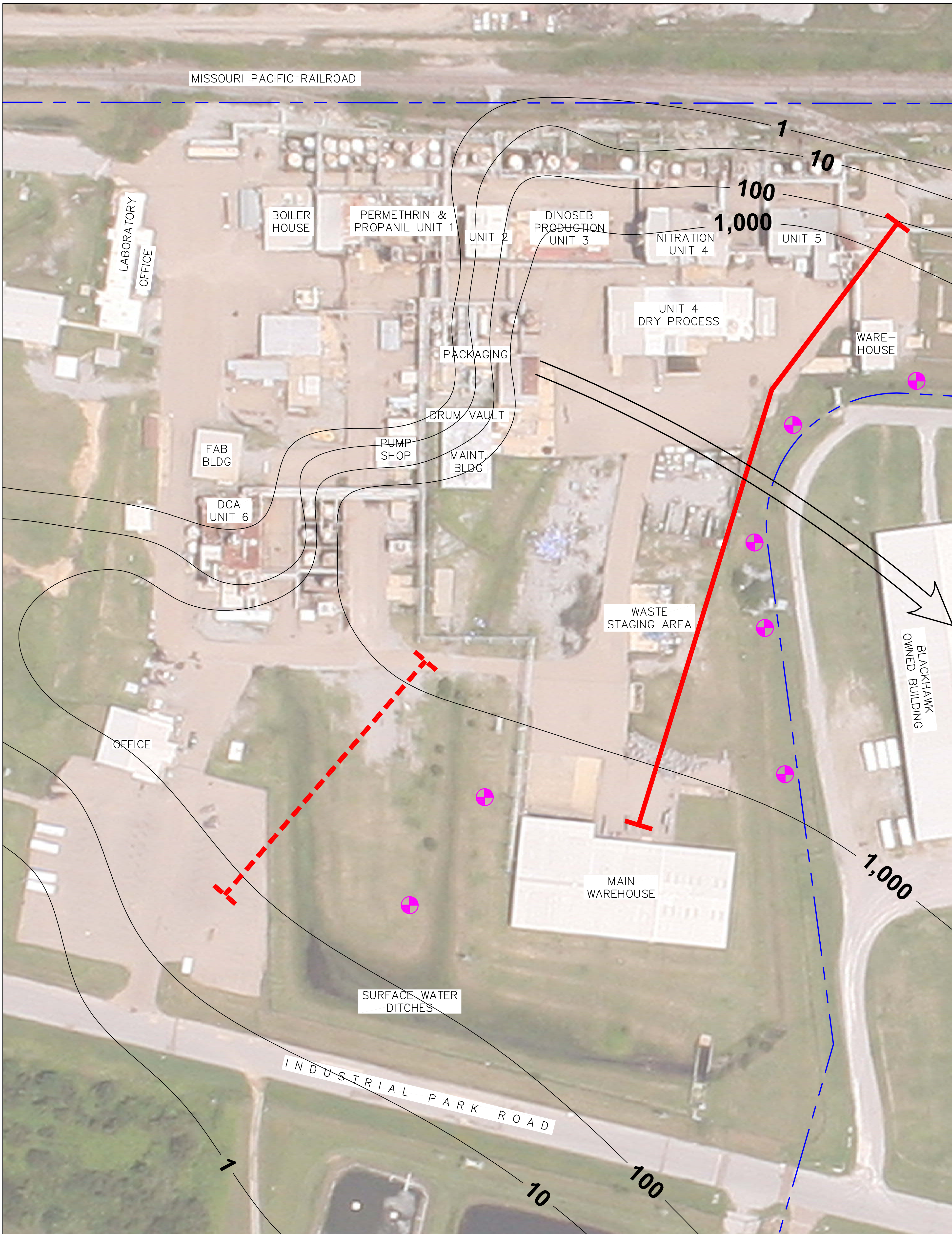


BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

PERCHED ZONE GROUNDWATER
REMEDY ALTERNATIVE P6
Permeable Reactive Barriers
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 14

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.



EXPLANATION

NEW MONITORING WELL

ALIGNMENT OF INJECTION WELLS ON ~10' SPACING

ALIGNMENT OF INJECTION WELLS ON 25' SPACING

GENERAL GROUNDWATER FLOW DIRECTION

— 1,000 — CONCENTRATION OF 1,2-DICHLOROETHANE IN GROUNDWATER AS OF SEPTEMBER 2008. UNITS ARE MICROGRAMS PER LITER (mg/L)

PROPERTY BOUNDARY

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

ALLUVIAL AQUIFER GROUNDWATER
REMEDY ALTERNATIVE A3
In Situ Enhanced Biodegradation
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 15

EXPLANATION

RECOVERY WELL CLUSTER (WELLS AT 70', 110' AND 150')

PIPING

PROPERTY BOUNDARY

1,000 CONCENTRATION OF 1,2-DICHLOROETHANE IN GROUNDWATER AS OF SEPTEMBER 2008. UNITS ARE MICROGRAMS PER LITER (mg/L)

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

ALLUVIAL AQUIFER GROUNDWATER
REMEDY ALTERNATIVE A4
Hydraulic Control
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13484.000
AMEC Geomatrix		Figure 16

EXPLANATION

INJECTION WELL CLUSTER (3 WELLS PER CLUSTER)

PIPING

PROPERTY BOUNDARY

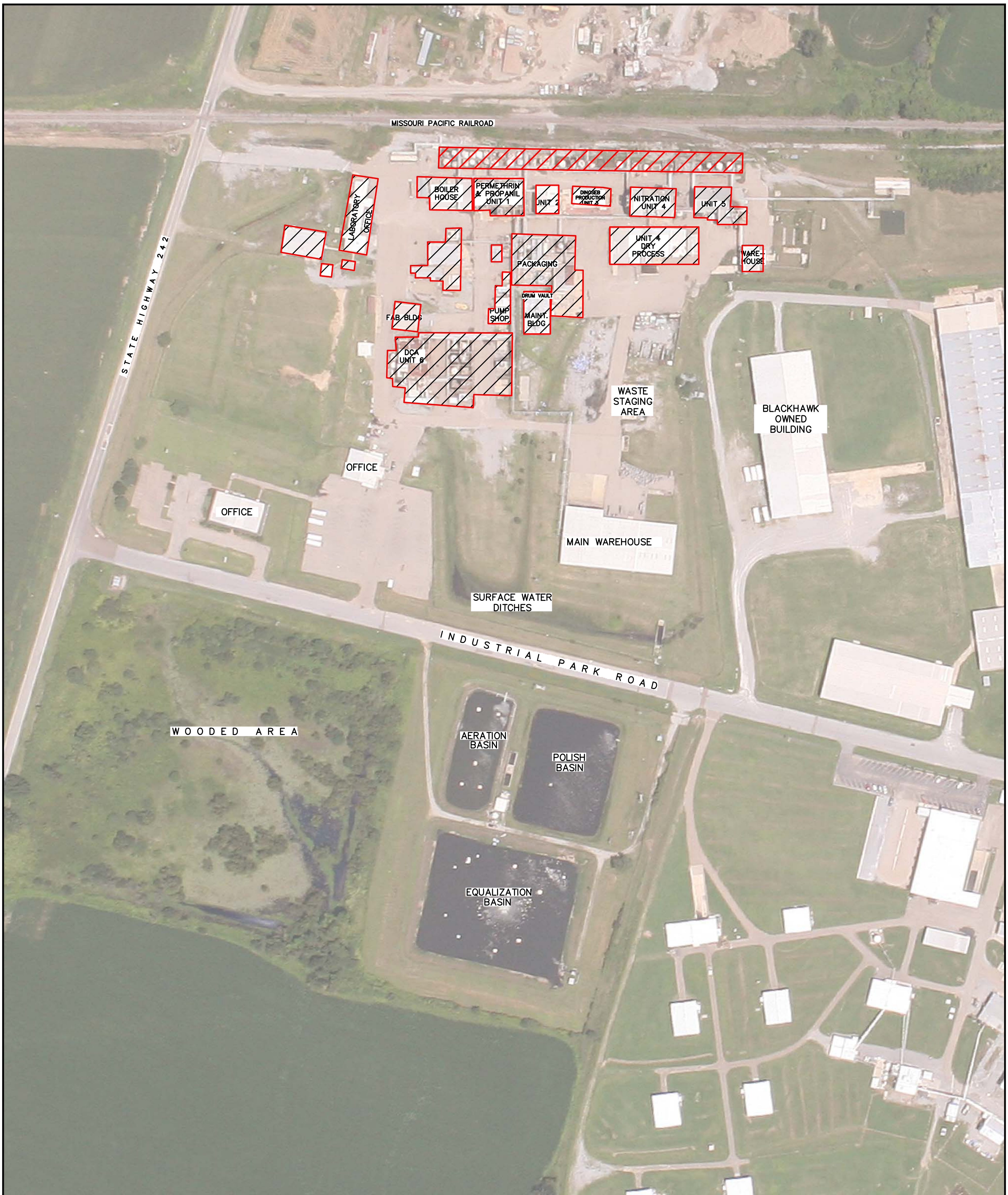
1,000 CONCENTRATION OF 1,2-DICHLOROETHANE IN GROUNDWATER AS OF SEPTEMBER 2008. UNITS ARE MICROGRAMS PER LITER (mg/L)

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

BASEMAP MODIFIED FROM:
Smith & Weiland/Cline-Fraizer Survey, August 2008

ALLUVIAL AQUIFER GROUNDWATER
REMEDY ALTERNATIVE A5
In Situ Chemical Oxidation
Cedar Chemical
Helena-West Helena, Arkansas

By: BAL	Date: 12/10/09	Project No. 13636.000
AMEC Geomatrix		Figure 17



EXPLANATION

BUILDINGS AND OTHER STRUCTURES TO BE REMOVED

NOTE: Boundaries, well locations, and remedy elements subject to change based on Remedial Design or other factors.

0 200
APPROXIMATE SCALE IN FEET

Demolition of On-Site Structures			
Cedar Chemical Helena-West Helena, Arkansas			
By: MLS	Date: 12/8/09	Project No. 13636	
AMEC Geomatrix		Figure 18	

Plot Date: 12/10/09 - 11:18am, Plotted by: mike.schofield
Drawing Path: I:\13636 - Arkansas Helena-West Helena\FIGURES\, Drawing Name: building_demo.dwg

APPENDIX A

Center for Toxicology and Environmental Health Human Health Risk Screening Report

Center for Toxicology and Environmental Health, L.L.C.

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Derivation of Human Health Risk-Based Concentrations Soil and Groundwater

Cedar Chemical Corporation Helena-West Helena, Arkansas

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Prepared for:
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1.0 INTRODUCTION

Investigations conducted at the former Cedar Chemical Corporation Facility (Site) have identified various chemicals in on-site soil, the shallow on-site Perched Zone (PZ) groundwater, and the deeper on-site and off-site Alluvial Aquifer (AA) groundwater. Historically, constituents consistently found in environmental media at the site have included: ketones, pesticides, herbicides, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). Certain constituents have migrated in groundwater beyond the Site boundary.

The Center for Toxicology and Environmental Health, LLC (CTEH) was contracted to review available soil and groundwater data for the Site, identify potential exposure pathways to chemicals in soil and groundwater, and select chemicals of potential concern (COPCs) based on comparison of maximum detected levels to United States Environmental Protection Agency 2007 Region 6 screening levels (USEPA SLs). For chemicals detected in groundwater, the higher of the maximum contaminant level or the USEPA SL was used for screening. Chemicals in soil and groundwater exceeding USEPA SLs were identified as COPCs. Following identification of the COPCs, site-specific risk-based concentrations (RBCs) or regulatory levels were determined for each COPC. Chemicals of concern (COCs) are those chemicals in on-site soil, PZ groundwater, and AA groundwater that exceed the RBCs or regulatory levels. Figures 1, 2, 3, and 4 illustrate the following five steps as they were applied to on-site soil, PZ groundwater, on-site AA groundwater, and off-site AA groundwater, respectively:

1) Compile a data set of chemical detections detected at the Site and its vicinity that are believed to represent contamination derived from releases of products, intermediates, wastes, and other materials from the former Site operations. This data set was derived from investigative work at the Site, including the data previously summarized in the Current Conditions Report (AMEC Geomatrix, Inc., November 2007) and Facility Investigation Report (AMEC Geomatrix, Inc., February 2009) previously submitted to the Arkansas Department of Environmental Quality (ADEQ).

2) Evaluate potential exposure pathways to chemicals in on-site soil and on-site and off-site groundwater. If no current exposure pathway exists for a given chemical, and such a pathway is highly unlikely to exist in the future, the chemical was not carried forward through the screening process (i.e., it was screened out from further consideration). For example, PZ groundwater is of insufficient yield to be used as a potable water supply. However, some volatile organic compounds (VOCs) may volatilize from shallow PZ groundwater and migrate into the indoor air of overlying buildings. This pathway is known as “vapor intrusion” pathway. The only exposure pathway of concern for the PZ on-site groundwater is therefore identified as the vapor intrusion pathway.

3) Screen the chemicals that were detected in on-site soil, PZ groundwater, on-site AA groundwater, and off-site AA groundwater, using health-protective USEPA 2007 Region 6 Human Health Medium-Specific Screening Levels (USEPA SLs). Those chemicals that exceeded a USEPA SL in soil or groundwater are termed “Chemicals of Potential Concern” (COPCs). In some cases, chemicals exceeding USEPA SLs in groundwater occurred infrequently (i.e., in less than 5% of samples analyzed), were analyzed in only one sample, or in the case of chemicals detected in soil, minimally exceeded health-protective SLs in only one or two samples. In these cases, the chemical was not selected as a COPC. Chemicals in soil eliminated as COPCs based on detection at levels only slightly above USEPA SLs are discussed in Section 3.1 of this report.

4) Derive a site-specific risk-based concentration (RBC) or select a regulatory level for each COPC identified in Step 3 (i.e., those for which there is a potentially complete exposure pathway). RBCs were calculated for COPCs in on-site soil for the direct contact and vapor intrusion pathways. Vapor intrusion-based RBCs were calculated for volatile COPCs in PZ groundwater. In the case of AA groundwater, the higher of the maximum contaminant level (MCL) or USEPA SL was used as the RBC.

5) Compare concentrations of COPCs identified in Step 3 to RBCs or regulatory limits determined in Step 4. Those COPCs which exceeded the RBC or the appropriate regulatory limit are termed Chemicals of Concern (COCs). The locations where the COCs exceed these values are listed for each COC in soil and groundwater. Information concerning the locations where these COCs occur in on-site soil and on- and off-site groundwater was used by AMEC Geomatrix to evaluate the possible need for remediation of soil and groundwater at the Site.

2.0 EXPOSURE ASSESSMENT

The objective of the exposure assessment is to evaluate potential pathways of human exposure to chemicals in soil and groundwater at the Site. If a potentially complete exposure pathway is identified for a specific chemical in site soils or groundwater (for example, ingestion of dieldrin in soil or exposure to 1,2-dichloroethane as a result of use of AA groundwater as a potable water supply) and the chemical exceeds a USEPA SL (Section 3 of this report), site-specific RBCs were calculated for each potential receptor (such as a commercial/industrial worker). The derivation of RBCs is discussed in Section 4 of this report. This section analyzes exposure conditions that may exist for current and future conditions at the Site.

2.1 Characterization of Exposure Setting

The Facility is located to the south of the city of Helena-West Helena, in Phillips County, Arkansas. The Facility consists of 48 acres within the Helena-West Helena Industrial Park, approximately 1.25 miles southwest of the intersection of U.S. Highway 49 and State Highway 242. The Facility is bordered by farmland, State Highway 242, a rail spur, and industrial park properties. The former operational portion of the property is divided into two major areas: (1) the abandoned manufacturing area and (2) the wastewater treatment system area which is located on the south side of Industrial Park Road. Of the 48 acres, approximately 40 acres comprise the abandoned manufacturing area of the Site. The 40 acre portion of the property is fenced and guarded by an on-site security guard. The current wastewater treatment ponds are located on an additional 8 acres of the property. An undeveloped, wooded area west of the wastewater treatment ponds and south of Industrial Park Road is part of the site property, but does not appear to have historically been part of the manufacturing facility.

2.2 Exposure Pathway Analysis

As stated by the USEPA, an exposure pathway

> "describes the course a chemical or physical agent takes from the source to the exposed individual. An exposure pathway analysis links the sources, locations, and types of environmental releases with population locations and activity patterns to determine the significant pathways of human exposure." (USEPA, 1989).

An exposure pathway is made up of four elements. These are:

- A source and mechanism of chemical release,
- A retention or transport medium,
- A point of potential human contact with the contaminated medium, and;
- An exposure route at the contact point.

The exposure pathways for chemicals in Site soil, PZ groundwater, and AA groundwater are discussed in the following subsections.

2.3 Exposure Pathways to Chemicals in Soil

On-site workers may directly contact chemicals in soil via incidental ingestion of soil, skin contact with soil, and inhalation of chemicals in soil particles or chemicals vaporizing from soil. In the future, it is possible that industrial workers at the Cedar Chemical site may be chronically exposed to the chemicals in soil. In addition, construction workers installing utilities or preparing the Site for future use may experience greater soil exposure for a shorter period of time. These direct contact pathways were therefore considered potentially complete for the on-site industrial worker and construction worker.

Soils ranging from the surface to 17 feet below ground surface (bgs) were considered to be potential sources of chemicals to which on-site workers may be directly or indirectly exposed.

The limit of vadose zone soils is approximately 17 feet bgs but direct contact with soil as deep as 17 feet bgs is unlikely. However, volatile organic compounds (VOCs) in deeper vadose zone soils may migrate through soil vapor and infiltrate an on-site building. The vapor intrusion pathway was therefore considered a potentially complete indirect exposure pathway to VOCs in on-site vadose zone soils. Through this pathway, on-site workers inside on-site buildings may inhale the VOCs released from soils underneath the building.

In summary, potential exposure pathways for on-site soils (to a depth of 17 feet bgs) are:

- Direct contact with soil by the ingestion, skin contact, and outdoor air inhalation pathways for on-site industrial worker and construction worker
- Vapor intrusion via migration of VOCs from soil into indoor air of overlying buildings where they are inhaled by on-site workers

2.4 Exposure Pathways to Chemicals in Groundwater

Generally, persons may contact chemicals in groundwater directly (i.e., via drinking or bathing in groundwater) or indirectly (such as via inhalation of chemicals volatilizing from groundwater used for irrigation). The potential for exposure to chemicals in PZ and AA groundwater is discussed below.

2.4.1 Perched Zone Groundwater

Direct contact with chemicals in on-site PZ groundwater was not considered to be a complete exposure pathway for future workers because PZ groundwater is not currently used for potable water supply, and there is no evidence that it has been so used in the past. The yield of PZ groundwater is also low. The low yield and lack of past and current use of PZ groundwater indicates that it is extremely unlikely that it would be used for potable water supply in the future. Therefore, the direct exposure pathway for on-site PZ groundwater was not considered in this evaluation.

However, potential indirect exposure to chemicals in PZ groundwater is dependent on the physical/chemical properties of the chemical. In the case of on-site PZ groundwater, the only potential exposure pathway to a chemical is indirectly via the vapor intrusion pathway when a chemical volatilizes from PZ groundwater into soil pore spaces and migrates into the indoor air of an on-site building.

In summary, the potential exposure pathway to PZ groundwater is

- Vapor intrusion via volatilization of VOCs from PZ groundwater into indoor air of overlying buildings where they are inhaled by indoor workers.

2.4.2 Alluvial Aquifer Groundwater

On-site AA groundwater is not used for potable purposes, and there is no known use of off-site AA groundwater as a domestic supply near the Site. Given the productivity and water quality of the AA groundwater, however, potable and/or domestic supply must be considered a potential future use. Direct contact with on- and off-site AA groundwater was therefore retained as a potentially complete exposure pathway.

Off-site AA groundwater may also be used to irrigate crops in fields surrounding the Site. Two possible indirect exposure pathways may result from the use of groundwater for irrigation—uptake of the chemical of potential concern in irrigation water into vegetable produce and inhalation of chemicals volatilizing from the irrigation water. Generally, chemicals considered to volatilize from groundwater (such as 1,2-dichloroethane) would not remain in irrigation water long enough to undergo significant uptake into vegetables. Bis(2-ethylhexyl)phthalate was detected in off-site alluvial groundwater and is not volatile. Due to metabolism, bis(2-ethylhexyl)phthalate does not accumulate in the food chain and is thus unlikely to be taken up into edible produce (ATSDR, 2002).

Given the use of off-site AA groundwater for irrigation, volatile chemicals may be released as vapor during the growing season, when large amounts of groundwater are used to irrigate fields. The potential for exposure to volatile compounds resulting from irrigation use of off-site groundwater at the Cedar Chemical Site was addressed by the Agency for Toxic Substances and Disease Registry (ATSDR) in a 2006 report (ATSDR, 2006). The ATSDR determined that, at a concentration of 27.1 mg/L in off-site groundwater, 1,2-dichloroethane (1,2- DCA) did not pose a human health concern, stating:

> Evaluation of groundwater sampling data and site-specific air dispersion modeling, completed in 2005, revealed levels of 1,2-DCA below its respective health comparison values and poses *No Apparent Public Health Hazard* to exposed individuals. (This category is used for sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.)

Based on the ATSDR's conclusion, and the fact that the current maximum observed 1,2-dichloroethane concentration is well below the 27.1 mg/L evaluated by ASTDR, the irrigation exposure pathway is not further evaluated in this report.

In summary, the potential exposure pathway retained for on- and off-site AA groundwater is:

- Direct contact with groundwater used as a potable water supply

3.0 DATA EVALUATION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN (COPCs)

3.1 On-Site Soil COPCs

Soil data are compiled from the Current Conditions Report, which summarizes soil data from historical investigations in 1993, 1994, and 1995, and the Facility Investigation Report, which summarizes soil data generated during the Facility Investigation in 2008. The 2007 USEPA industrial outdoor worker soil SLs were used to select COPCs in soil. An on-site worker is unlikely to directly contact chemicals in soil deeper than 10 feet bgs. However, because of possible vapor intrusion concerns from COPCs in deeper soils, selection of COPCs in soil was evaluated for the 0 to 17 feet bgs soil profile. A maximum depth of 17 feet is used because PZ groundwater is typically encountered on-site at approximately that depth. Soils deeper than this level would therefore not represent vadose zone soils. Summary statistics for COPCs in 0 to 17 feet bgs soils are presented in Table 1.

Chloroform, methylene chloride, and tetrachloroethene were detected in only one or two samples above their respective USEPA Region SLs, and were addressed as follows:

- For chloroform, the only soil concentration greater than the screening level of 0.52 mg/kg was sample 2SB-12 collected at a depth of 15 to 20 feet. The concentration of chloroform (0.62 mg/kg) was only slightly above its screening level of 0.52 mg/kg. Because it was detected in a single sample at a concentration only slightly above its screening level, chloroform was not retained as a COPC.
- Methylene chloride was also detected above its screening level of 22 mg/kg in only one sample. Sample 2SB-12 collected at a depth of 15 to 20 feet bgs contained 45 mg/kg methylene chloride. Given that only a single sample exceeded the screening level, methylene chloride was not retained as a COPC.
- Tetrachloroethene was detected in only two samples slightly above the screening level of 1.8 mg/kg. Samples DPT-3 from a depth of 16 to 20 feet bgs contained 2.5 mg/kg and sample DPT-10 from a depth of 0 to 4 feet bgs contained 2.1 mg/kg. Given that only two samples exceeded the screening level, and the amount of the exceedance was small, tetrachloroethene was not retained as a COPC.

Based on the comparison of maximum detected chemical concentrations in soil to USEPA industrial outdoor worker soil SLs, the following chemicals were identified as COPCs for the derivation of RBCs in soil: aldrin, arsenic, chlordane (technical), 1,2 dichloroethane, dieldrin, dinoseb, beta-hexachlorocyclohexane (beta-BHC), gamma-hexachlorocyclohexane (gamma-BHC or lindane), propanil, and toxaphene. As outlined in Figure 1 and as discussed in Section 4.1 of this report, RBCs were derived for the direct contact pathway for the industrial worker and construction worker for each COPC identified in soil. In addition, some COPCs are considered to be volatile for the vapor intrusion pathway. These COPCs are aldrin, chlordane, 1,2 dichloroethane, dieldrin, and beta-hexachlorocyclohexane (b-BHC). COPCs exceeding either the direct contact RBC or the vapor intrusion based RBC were selected as COCs in soil (Figure 1).

Although the USEPA Region 6 has developed screening levels for chemicals in soil that are protective of groundwater, these values were not used in the screening process. Groundwater in the PZ and AA has already experienced impact from chemicals released to site soils, so the groundwater protective levels are no longer useful as an indicator of a potential threat to groundwater. With regard to the potential for future impacts to groundwater, actual groundwater monitoring data will be used, and will be more directly representative of site conditions than comparisons of soil concentrations to groundwater protective levels. In summary, groundwater protective levels for soil are not considered pertinent to the risk assessment and remedy selection/implementation processes at this site, and are not used in this evaluation.

3.2 Groundwater COPCs

Groundwater data considered in this assessment are from the 2008 Facility Investigation Report. COPCs were identified by comparing detected concentrations with USEPA health-protective screening levels presented in USEPA's Region 6 Human Health Medium Specific Screening Levels (USEPA, 2007). Although some chemicals exceeded USEPA screening levels, they were detected in less than 5% of samples analyzed or were analyzed and detected in only a single sample. Due to infrequent detection, these chemicals were not selected as COPCs.

Discussion of COPCs in groundwater is organized into three sections; COPCs in the PZ groundwater (Table 2), COPCs on-site AA groundwater (Table 3A), and COPCs in off-site AA groundwater Table 3B). The PZ groundwater overlies the deeper AA groundwater. Both the PZ and AA groundwater have been sampled on-site, whereas off-site sampling results are available only for AA groundwater.

3.2.1 Perched Zone Groundwater COPCs

Figure 2 summarizes the process used to select COCs in PZ groundwater. Groundwater sampling data from 2008 presented in the Facility Investigation Report were used to select COPCs in on-site PZ groundwater. As discussed in Section 2.4.1 of this report, PZ groundwater is not used for potable purposes at the Site and the potentially complete pathway of exposure to chemicals in PZ groundwater is indirectly via vapor intrusion. However, USEPA Region 6 provides no SLs for groundwater for the vapor intrusion pathway. For this reason, chemicals in PZ groundwater are screened using the higher of the MCL or USEPA SLs for residential water for those chemicals. Additional screening criteria for chemicals detected in PZ groundwater were that the chemical must be detected in more than one sample (some chemicals were analyzed and detected only once) or detected in 5% or more of the samples analyzed. In addition, the chemical must be considered volatile by the USEPA to be of concern for the vapor intrusion pathway.

Although selection of VOCs in PZ groundwater as COPCs using MCLs or USEPA residential SLs identifies some chemicals that may not pose a vapor intrusion concern, it ensures that the COPC selection process is biased to the protection of on-site workers. Volatile chemicals selected as COPCs for PZ groundwater using the health-protective process described above are presented in Table 2. These volatile chemicals are acetone, aldrin, 2-butanone, chlorobenzene, chloroform, 1,2-dichlorobenzene, 1,2-dichloroethane, dieldrin, ethylbenzene, gamma-hexachlorocyclohexane (g-BHC), 4-methyl 2-pentanone, methylene chloride, toluene, and m- and p-xylene. The calculation of vapor intrusion-based RBCs for these chemicals in PZ groundwater is discussed in Section 4.2.1 of this report.

3.2.2 Alluvial Aquifer Groundwater COPCs

The AA groundwater data evaluated in this report were limited to the September 2008 and November 2008 sampling rounds because these are the most recent data and are most representative of current conditions at the Site. Maximum concentrations of chemicals detected in AA groundwater were compared to the higher of the MCL or the USEPA SL for residential water (USEPA, 2007).

Selection of COPCs in on-site AA groundwater is summarized in Figure 3 and Table 3A. Chemicals selected as COPCs in on-site AA groundwater were aldrin, aniline, arsenic, benzene, b-BHC, bis(2-chloroethyl) ether, 4-chloroaniline, chlorobenzene, chloroethane, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,2-dichloroethane, vinyl chloride. For reasons discussed in Section 4.2.2 of this report, all COPCs identified in on-site AA groundwater are also considered COCs.

Selection of COPCs in off-site AA groundwater is summarized in Figure 4 and Table 3B. Chemicals selected as COPCs in off-site AA groundwater were bis(2-chloroethyl) ether, bis(2-ethylhexyl) phthalate, chromium, 1,2-dichloroethane. For reasons discussed in Section 4.2.2 of this report, all COPCs identified in off-site AA groundwater are also considered COCs.

4.0 DEVELOPMENT OF RISK-BASED CONCENTRATIONS

As discussed in Section 2, potentially complete exposure pathways were identified for the following media:

- Soils – direct contact for on-site industrial workers and construction workers; and vapor intrusion for on-site workers
- Perched Zone Groundwater – vapor intrusion for on-site workers
- Alluvial Aquifer Groundwater – use of groundwater as a potable water supply

RBCs were developed for each pathway for those COPCs that exceeded screening levels. The RBCs developed for on-site soil, PZ groundwater, on-site AA groundwater, and off-site AA groundwater are discussed below. COPCs that exceeded RBCs were selected as COCs.

4.1 Soil

As summarized in Figure 1, soil RBCs were determined for the direct contact exposure pathway for on-site industrial workers and construction workers. Soil RBCs were also determined for the vapor intrusion pathway for COPCs that are volatile. The lowest of the three soil RBCs (i.e., direct contact RBC for the on-site industrial worker, direct contact RBC for the on-site construction worker, and the vapor intrusion RBC) was used as the final RBC for soil. Table 4 presents RBCs for the direct contact and vapor intrusion pathways and presents the final, most stringent RBC used to assess the need remediation or institutional control.

In summary, based on comparison to the most stringent RBC, the following five chemicals were identified as COCs in on-site soil: arsenic, dieldrin, dinoseb, 1,2-dichloroethane, and gamma-hexachlorocyclohexane (g-BHC). Concentrations of these COCs and the soil sample locations where they occur are also presented in Table 4. The five COCs in soil are addressed in the Feasibility Study report (FS report) prepared by AMEC Geomatrix.

Determination of soil RBCs for the direct contact and vapor intrusion pathways is described below.

4.1.1 Risk-based concentrations for direct contact

RBCs for 0 to 17 feet bgs soils were developed for the on-site industrial worker and construction worker. USEPA default exposure assumptions were used to calculate RBCs.

USEPA procedures for estimating emissions of VOCs from soil were used to estimate 1,2-dichloroethane emissions from soil. The RBC developed for 1,2-dichloroethane is sensitive to geographic location and size of the area affected. To make this RBC more specific to the Helena-West Helena area, default EPA inputs for VOC emissions for Little Rock were used. The RBC for 1,2-dichloroethane in on-site soil was calculated for a 40 acre property.

For the purpose of calculating outdoor inhalation exposures from soil, the remaining COPCs are semi-volatile or non-volatile and may be inhaled as particulates. During construction, it was assumed that the airborne dust concentration is 1 mg/m^3 and that the dust is entirely derived from Site soil.

RBCs for the on-site industrial worker and construction worker were based on an excess lifetime cancer risk of 1×10^{-5} for aldrin, arsenic, chlordane, 1,2 dichloroethane, dieldrin, beta-hexachlorocycolhexane (beta-BHC), gamma-hexachlorocyclohexane (gamma-BHC or lindane), and toxaphene. For dinoseb and propanil, the RBCs are based on a noncancer hazard index of 1.

RBCs for the on-site industrial worker and construction worker directly contacting COPCs in soil are presented in Table 4. Equations and assumptions used for calculation of RBCs for direct contact with soil are presented in Attachment A.

4.1.2 Risk-based concentrations for vapor intrusion

The USEPA's advanced version of the Johnson and Ettinger (J&E) vapor intrusion model for soil (SL-ADV; Version 3.1; 02/04) was used to calculate RBCs for volatile chemicals detected in on-site soil above USEPA Region 6 worker screening levels. Soil RBCs for the vapor intrusion pathway were calculated for aldrin, gamma-BHC, chlordane, 1,2-dichloroethane, and dieldrin (Table 4).

The site-specific depth to groundwater at the site is assumed to be 17 feet bgs and the soil type was assumed to be silty clay (SIC). All other parameters used in the development of soil RBCs for the vapor intrusion pathway such as building air changes per hour (commercial/industrial scenario), building dimensions (commercial/industrial scenario only), and vapor intrusion model parameters were set to regulatory defaults.

Currently, security guards occupy the on-site building during 12 hour shifts. For the on-site vapor intrusion exposure pathway, workers were assumed to be exposed for 12 hours per day, 250 days per year for 25 years. Because the USEPA vapor intrusion model does not account for exposure for a fraction of a day, the soil RBC calculated for the on-site worker using the USEPA version of the Johnson and Ettinger vapor intrusion model was multiplied by 2 to account for the fact that workers are exposed for 12 hours (rather than 24 hours) per day.

The vapor intrusion RBCs for potential carcinogens are based on a target excess lifetime cancer risk of 1×10^{-5}. RBCs for all other chemicals were based on a hazard quotient of 1 for noncancer effects.

RBCs calculated for the COPCs in on-site soil for the vapor intrusion pathway are presented in Table 4. Outputs from the USEPA soil vapor intrusion model are presented in Attachment B.

4.2 Groundwater

4.2.1 Perched Zone Groundwater

RBCs for on-site PZ groundwater are based on the vapor intrusion pathway. This pathway assumes that on-site workers will inhale VOCs in indoor air as a result of volatilization from perched groundwater, migration through vadose zone soils, and infiltration into an on-site building. The USEPA's advanced version of the Johnson and Ettinger (J&E) vapor intrusion model for groundwater (GW-ADV; Version 3.1; 02/04) was used to calculate RBCs for volatile chemicals detected in on-site perched groundwater at concentrations above MCLs or residential SLs. Based on information presented in the Current Conditions report, the site-specific depth to groundwater at the site is assumed to be 17 feet bgs and the soil type was assumed to be silty clay (SIC). With the exception of the soil/groundwater temperature (commercial/industrial and residential scenarios), building air changes per hour (commercial/industrial scenario only), building dimensions (commercial/industrial scenario only), vapor intrusion model parameters were set to USEPA defaults. Non-default parameters used in the models are presented in the tables below.

Vapor Intrusion Model Inputs

Parameter	Value Used	Comment
Soil/Groundwater Temperature	17° C	Specific to Arkansas
Enclosed space floor length	2440 cm	On-site office approximately 80 feet long
Enclosed space floor width	2440 cm	On-site office approximately 80 feet wide
Air changes per hour	1 air change per hr	Cal-EPA, 2005

As with the vapor intrusion pathway for soil, workers were assumed to be exposed 250 days per year for 25 years for 12 hours per day. As stated above, the USEPA vapor intrusion model does not account for exposure for a fraction of a day and the RBC calculated for the on-site worker using the USEPA version of the Johnson and Ettinger vapor intrusion model was multiplied by 2 to account for the fact that workers are exposed for 12 hours (rather than 24 hours) per day.

Outputs from the USEPA vapor intrusion model are presented in Attachment C.

The RBCs for potential carcinogens are based on a target excess lifetime cancer risk of 1×10^{-5}. RBCs for all other chemicals were based on a hazard quotient of 1 for noncancer effects.

RBCs calculated for volatile COPCs in on-site PZ groundwater are presented in Table 5.

In summary, chloroform and 1,2-dichloroethane were selected as COCs in PZ groundwater. Sampling locations where chloroform and 1,2-dichloroethane concentrations exceed vapor intrusion-based RBCs are presented in Table 6. Chloroform and 1,2-dichloroethane in PZ groundwater are addressed as COCs in the FS report.

4.2.2 Alluvial Aquifer Groundwater

As stated in Section 2 of this report, possible future use of alluvial groundwater as a potable water supply cannot be precluded. Both the MCL and the USEPA residential screening level are considered protective with respect to use of groundwater for potable supply. As discussed in Section 3.2.2 of this report, the higher of the MCL or the USEPA residential screening level (for those chemicals that have both) was used for screening COPCs. The MCL/USEPA SL are also the most appropriate values for selecting COCs in potable groundwater. For this reason, all COPCs identified in on-site and off-site AA groundwater are also considered COCs.

In summary, 13 COCs in on-site AA groundwater are aldrin, aniline, arsenic, benzene, b-BHC, bis(2-chloroethyl) ether, 4-chloroaniline, chlorobenzene, chloroethane, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,2-dichloroethane, and vinyl chloride. Locations and concentrations of COCs in on-site AA groundwater that exceed RBCs are presented in Table 3A. The 13 COCs in on-site AA groundwater are addressed in the FS report.

The four COCs in off-site AA groundwater are bis(2-chloroethyl) ether, bis(2-ethylhexyl) phthalate, chromium, and 1,2-dichloroethane. Sampling locations and concentrations of COCs in off-site AA groundwater that exceed RBCs are presented in Table 3B. The four COCs in off-site AA groundwater are addressed in the FS report.

5.0 REFERENCES

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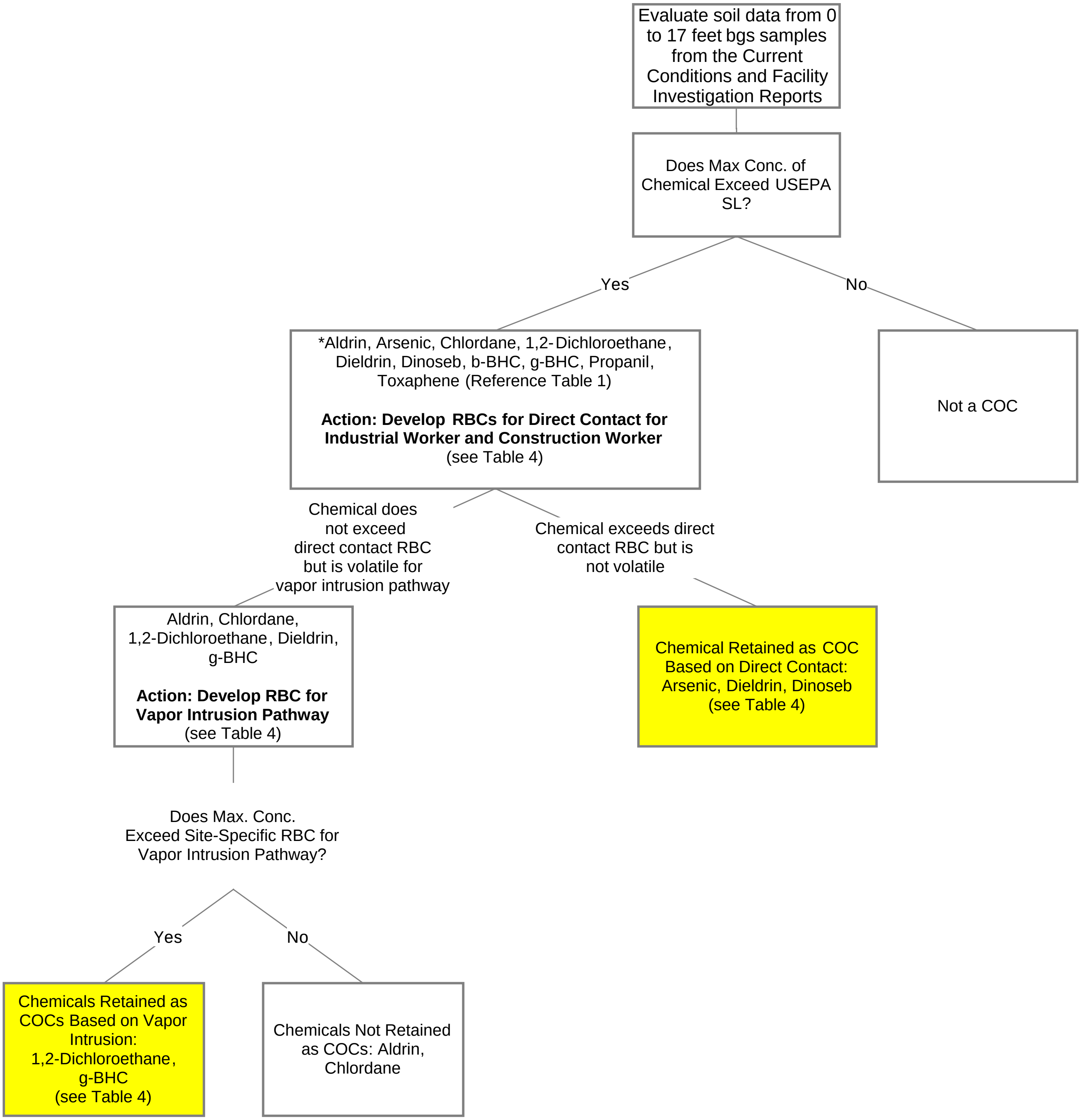
FIGURES

Figure 1
Selection of Chemicals of Concern (COCs):
On-site Soil

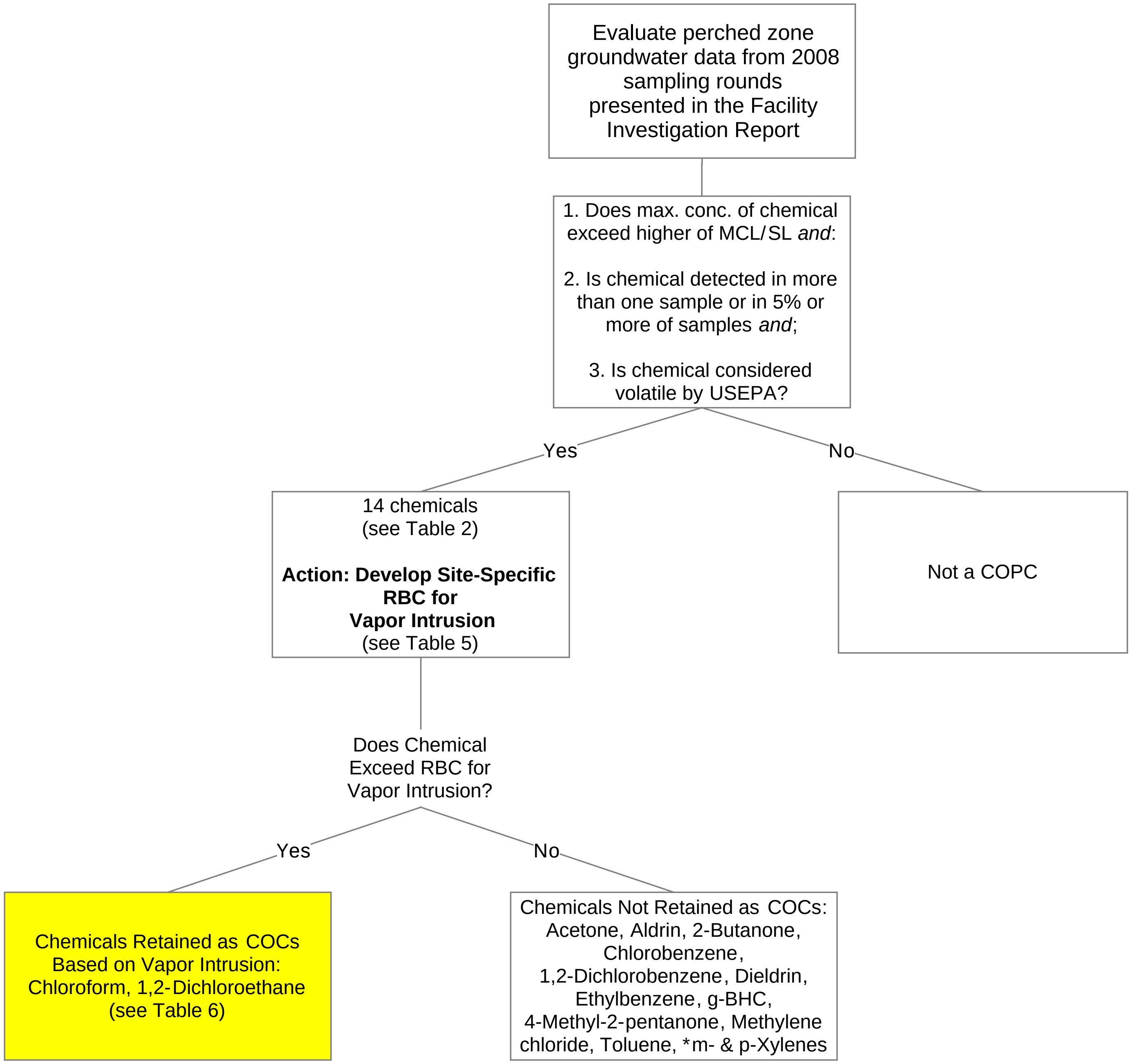


Summary:
Chemicals of Concern Based on Direct Contact Exposure Pathway:
Arsenic, Dieldrin, Dinoseb

Chemicals of Concern Based on Vapor Intrusion Pathway:
1,2-Dichloroethane, g-BHC

SL = USEPA direct contact industrial soil screening level
RBC = site-specific risk-based concentration
*Although chloroform, methylene chloride, and tetrachloroethene also exceeded USEPA SLs, the amount of the exceedence was very low and these chemicals were not selected as COPCs. See discussion in Section 3.1 of report.

Figure 2
Selection of Chemicals of Concern (COCs):
On-site Perched Zone Groundwater

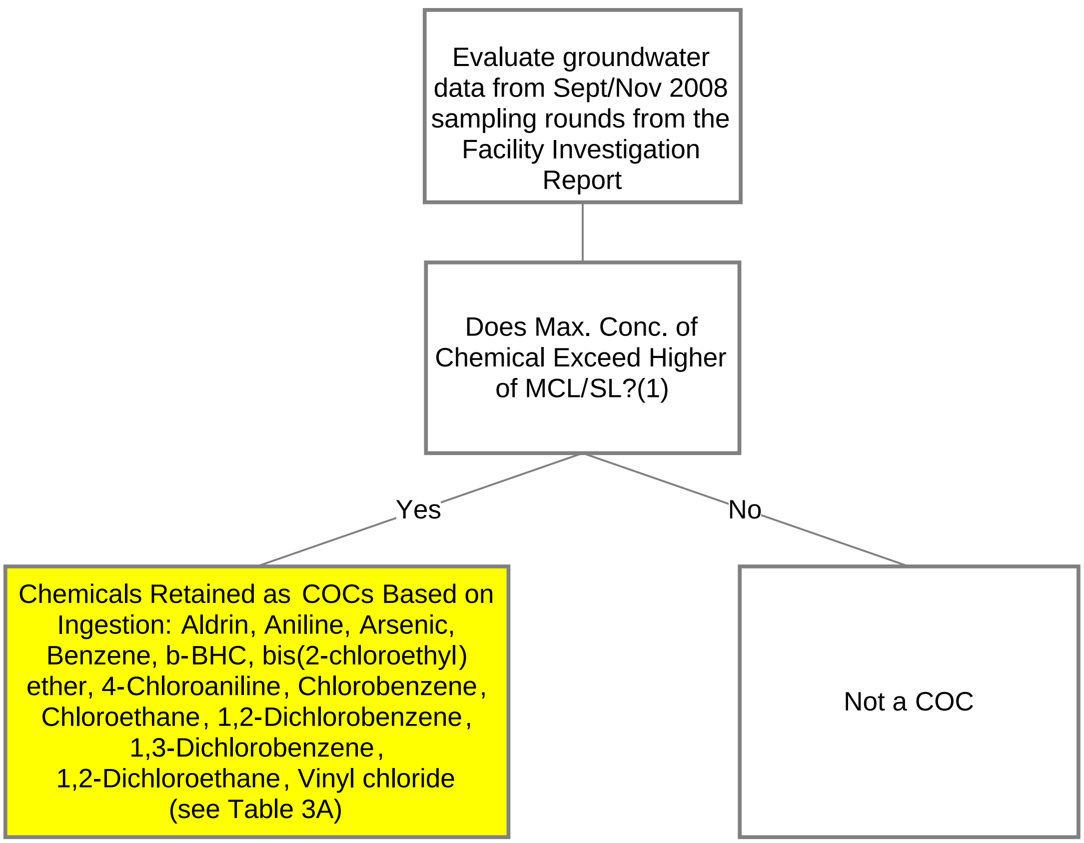


Summary:
Chemicals of Concern Based on Vapor Intrusion Exposure Pathway:
Chloroform, 1,2-Dichloroethane

MCL = federal maximum contaminant level in drinking water
RBC = site-specific risk-based concentration developed by CTEH
SL = USEPA Region 6 screening level for residential water (2007)

*Vapor intrusion RBC for m- & p-Xylenes exceeded water solubility (161,000 ug/L);
one sample at TW-4 at a concentration of 220,000 ug/L exceeded the solubility limit for m- & p-Xylenes

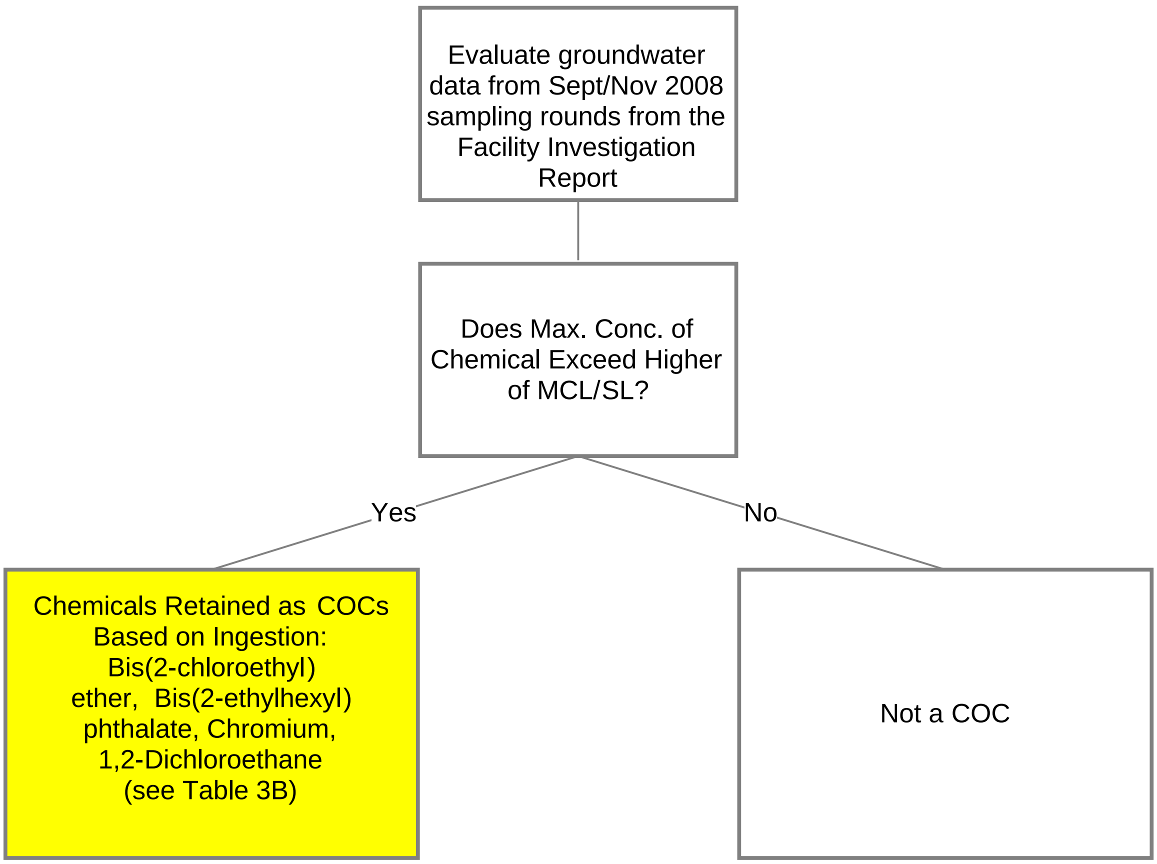
Figure 3
Selection of Chemicals of Concern (COCs):
On-site Alluvial Aquifer Groundwater



Summary:
Chemicals of Concern Based on Potable Water Exposure Pathway:
Aldrin, Aniline, Arsenic, Benzene, beta-BHC, bis(2-chloroethyl) ether, 4-Chloroaniline, Chlorobenzene Chloroethane, 1,2-Dichlorobenzene, 1,3-Dichlorobenzene, 1,2-Dichloroethane, Vinyl chloride

MCL = federal maximum contaminant level in drinking water
SL = USEPA Region 6 screening level for residential water (2007)

Figure 4
Selection of Chemicals of Concern (COCs):
Off-site Alluvial Aquifer Groundwater



Summary:
Chemicals of Concern Based on Residential Water Direct Exposure Pathway:
Bis(2-chloroethyl) ether, Bis(2-ethylhexyl)phthalate, Chromium, 1,2-Dichloroethane

MCL = federal maximum contaminant level in drinking water
SL = USEPA Region 6 screening level for residential water (2007)

TABLES

Table 1
Chemicals of Potential Concern in On-Site Soil
Cedar Chemical Site

Chemical	Number of Detects	Number of Analyses	Maximum Detected Concentration (mg/kg)	*Industrial Outdoor Worker Screening Level (mg/ kg)	Does Maximum Detected Concentration Exceed Sceening Level?
Aldrin	25	255	2.2	0.11	YES
Arsenic	165	177	128	1.8	YES
Chlordane	1	98	130	7.2	YES
**Chloroform	20	299	0.62	0.58	YES
Dichloroethane, 1,2-	56	211	8.4	0.84	YES
Dieldrin	43	254	15	0.12	YES
Dinoseb	197	345	29000	680	YES
Hexachlorocyclohexane, beta-	18	254	2.8	1.4	YES
Hexachlorocyclohexane, gamma-	17	255	45	1.9	YES
**Methylene chloride	71	211	45	22	YES
Propanil	61	223	4000	3400	YES
**Tetrachloroethene	19	211	2.5	1.7	YES
Toxaphene	2	254	14	1.7	YES

*from USEPA Region 6 Human Health Medium
Specific Screening Levels (12/4/2007)
**Although chemical excceds screening level, it was not considered a COPC for reasons discussed in Section 3.1

Table 2
Chemicals of Potential Concern (COPCs) in Perched Zone Groundwater
Cedar Chemical Site

Chemical	Number of Detects	Number of Analyses	Maximum Detected Concentration (ug/L)	Maximum Contaminant Level (ug/L)	Does maximum detected concentration exceed MCL?	*USEPA Region 6 Residential water level (2007 value) (ug/L)	Does maximum detected concentration exceed USEPA Region 6 residential water level?	Does USEPA consider chemical volatile?	Chemical is a COPC?
Acetone	34	52	33000	NA	NA	5500	YES	YES	YES
Aldrin	3	43	0.11	NA	NA	0.004	YES	YES	YES
Butanone, 2- (MEK)	10	53	15000	NA	NA	7100	YES	YES	YES
Chlorobenzene	22	55	190	100	YES	91	YES	YES	YES
Chloroform	5	53	13000	**80	YES	0.17	YES	YES	YES
Dichlorobenzene, 1,2-	47	95	10000	600	YES	49	YES	YES	YES
Dichloroethane, 1,2-	37	52	730000	5	YES	0.12	YES	YES	YES
Dieldrin	5	43	1.8	NA	NA	0.0042	YES	YES	YES
Ethylbenzene	13	52	51000	700	YES	1300	YES	YES	YES
Hexachlorocyclohexane, gamma-	7	43	110	0.2	YES	0.052	YES	YES	YES
Methyl-2-pentanone, 4- (MIBK)	9	54	10000	NA	NA	7100	YES	YES	YES
Methylene chloride	14	54	26000	5	YES	4.3	YES	YES	YES
Toluene	20	55	210000	1000	YES	2300	YES	YES	YES
Xylene, m- & p-	8	53	220000	NA	NA	210	YES	YES	YES

NA - not available
ND - not detected
*USEPA Region 6 Human Health Medium-Specific Screening Levels (12/4/2007)
**Value for total trihalomethanes

Table 3A
Chemicals of Concern in On-Site Alluvial Aquifer Groundwater
September and November 2008 Sampling Rounds
Cedar Chemical Site

Chemical	Number of Detects	Number of Analyses	Maximum Detected Concentration (ug/L)	Maximum Contaminant Level (ug/L)	Does maximum detected concentration exceed MCL?	*USEPA Region 6 Residential water level (2007 value) (ug/L)	Does maximum detected concentration exceed USEPA Region 6 residential water level?	Locations where concentration exceeds greater of MCL or USEPA residential water level	Maximum Concentration in Sept/Nov. 2008 at Location
Aldrin	4	29	0.053	NA	NA	0.004	YES	2MW-3	0.053
								2MW-4	0.046
Aniline	3	29	18	NA	NA	12	YES	MW-15	18
Arsenic	29	29	152	10	YES	0.045	YES	2MW-3	152
								9MW-1	49.7
								2MW-4	44.2
								MW-15	30.7
								4MW-4	20.4
								MW-13	18.9
								2MW-7	17.6
Benzene	5	29	21	5	YES	0.35	YES	MW-15	21
								2MW-4	8
								MW-22#4	7
bis(2-Chloroethyl) ether	5	29	41	NA	NA	0.0098	YES	2MW-3	34
								4MW-4	9.1
								MW-22#4	4.1
								2MW-4	3.1
								4MW-3	1.1
Chloroaniline, 4-	9	29	3000	NA	NA	150	YES	MW-15	3000
								2MW-4	2100
								EMW-6A	800
Chlorobenzene	11	33	310	100	YES	91	YES	2MW-4	310
								MW-15	110
Chloroethane	4	29	11	5	YES	4.3	YES	2MW-3	11
Dichlorobenzene, 1,2-	16	58	1100	600	YES	49	YES	2MW-4	1100
Dichlorobenzene, 1,3-	2	58	90	NA	NA	14	YES	4MW-3	90

NA - not available
*USEPA Region 6 Human Health Medium-Specific Screening Levels (12/4/2007)
**Value for total trihalomethanes

Table 3A
Chemicals of Concern in On-Site Alluvial Aquifer Groundwater
September and November 2008 Sampling Rounds
Cedar Chemical Site

Chemical	Number of Detects	Number of Analyses	Maximum Detected Concentration (ug/L)	Maximum Contaminant Level (ug/L)	Does maximum detected concentration exceed MCL?	*USEPA Region 6 Residential water level (2007 value) (ug/L)	Does maximum detected concentration exceed USEPA Region 6 residential water level?	Locations where concentration exceeds greater of MCL or USEPA residential water level	Maximum Concentration in Sept/Nov. 2008 at Location
Dichloroethane, 1,2-	15	29	4900	5	YES	0.12	YES	EMW-7	1600
								9MW-1	1500
								MW-13	1100
								2MW-4	660
								4MW-3	330
								EMW-6A	220
								MW-22#1	120
								MW-22#4	27
								MW-17	9
								4MW-4	8.5
								2MW-3	6.8
Hexachlorocyclohexane, beta (b-BHC)	2	29	0.046	NA	NA	0.037	YES	2MW-3	0.046
Vinyl chloride	2	29	10	2	YES	0.015	YES	MW-13	10

NA - not available
*USEPA Region 6 Human Health Medium-Specific Screening Levels (12/4/2007)
**Value for total trihalomethanes

Table 3B
Chemicals of Concern in Off-Site Alluvial Aquifer Groundwater
September and November 2008 Sampling Rounds
Cedar Chemical Site

Chemical	Number of Detects	Number of Analyses	Maximum Detected Concentration (ug/L)	Maximum Contaminant Level (ug/L)	Does maximum detected concentration exceed MCL?	*USEPA Region 6 Residential water level (2007 value) (ug/L)	Does maximum detected concentration exceed USEPA Region 6 residential water	Locations where concentration exceeds greater of MCL or USEPA residential water level	Maximum Concentration at Location in Sept/Nov. 2008
bis(2-Chloroethyl) ether	2	23	4.6	NA	NA	0.0098	YES	OFFMW-3	4.6
								OFFMW-7#5	0.7
bis(2-Ethylhexyl) phthalate	5	23	300	6	YES	4.8	YES	OFFMW-11#1	300
Chromium	14	23	145	100	YES	NA	NA	OFFMW-9#2	145
Dichloroethane, 1,2-	13	23	19000	5	YES	0.12	YES	OFFMW-6#5	19,000
								OFFMW-6#3	18,000
								OFFMW-6#1	4800
								OFFMW-8#5	3000
								OFFMW-11#1	1300
								OFFMW-11#2	760
								OFFMW-3	66
								OFFMW-7#5	52
								OFFMW-7#4	49
								OFFMW-7#6	48

NA - not available
*USEPA Region 6 Human Health Medium-Specific Screening Levels (12/4/2007)
**Value for total trihalomethanes

Table 4
Risk-Based Concentrations for Chemicals of Potential Concern (COPCs) in Soil and Locations Exceeding Risk-Based Concentrations (RBCs)
Cedar Chemical Site

Chemical	Industrial Worker (mg/kg)	Construction Worker (mg/kg)	Vapor Intrusion Pathway (mg/kg)	Most Protective RBC (mg/kg)	Basis for More Protective RBC	Soil Locations Exceeding RBC	Concentration in sample (mg/kg)
Aldrin	1.01	9.66	>87.4	1.01	Excess lifetime cancer risk of 1 x 10^{-5} for industrial worker	None	NA
Arsenic	16	112	NA	16	Excess lifetime cancer risk of 1 x 10^{-5} for industrial worker	DPT-10 (0-4')	128
						2HA-5 (0-1')	98.1
						DPT-3 (0-4')	78.7
						2HA-5 (0-1')DUP	68.8
						IMSB-1 (1-3')	59.0
						1HA-2 (0-1')	44.6
						VAULT HOLE#4	43.6
						DPT-30(0-4')	32.3
Chlordane (technical)	64.7	543	NA	64.7	Excess lifetime cancer risk of 1 x 10^{-5} for industrial worker	None	NA
1,2 Dichloroethane	11.9	10.9	0.354	0.354	Excess lifetime cancer risk of 1 x 10^{-5} for vapor intrusion	1HA-5 (0-1')	7.5
						DPT-10 (12-16')	1.6
						SAI-23 (10-12')	1.1
						DPT-7 (12-16')	1
						2SB-13 (8-10')	0.81
						2SB-13 (10-12')	0.74
						DPT-10 (0-4')	0.4
Dieldrin	1.08	10	>9.16	1.08	Excess lifetime cancer risk of 1 x 10^{-5} for industrial worker	DPT-26(2-4')	15
						DPT-27(0-2')	8.2
						DPT-25(2-4')	4.9
						DPT-15(2-4')	4
						DPT-20(2-4')	1.8

NA - not applicable

Table 4
Risk-Based Concentrations for Chemicals of Potential Concern (COPCs) in Soil and Locations Exceeding Risk-Based Concentrations (RBCs)
Cedar Chemical Site

Chemical	Industrial Worker (mg/kg)	Construction Worker (mg/kg)	Vapor Intrusion Pathway (mg/kg)	Most Protective RBC (mg/kg)	Basis for More Protective RBC	Soil Locations Exceeding RBC	Concentration in sample (mg/kg)
Dinoseb	616	238	NA	238	Hazard quotient of 1 for construction worker	9SB-5 (0-5')	29,000
						9SB-9 (0-5')	28,000
						9SB-7 (0-5')	26,000
						9SB-4 (0-5')	24,000
						9SB-8 (0-5')	15,000
						3SB-6 (4-8')	13,000
						9SB-12 (0-5')	13,000
						9SB-4 (5-10')	8500
						9SB-7 (5-10')	6400
						DPT-35(12-16')	4900
						9SB-5 (5-10')	4100
						DPT-28(8-12')	1800
						9SB-5 (10-15')	1700
						4HA-2 (1-2')	1100
						DPT-27(0-2')	950
						4HA-5 (2-3')	920
						4HA-7 (5-6')	840
						9SB-10 (0-5')	650
						DPT-23(2-4')	600
						3SB-6 (12-16')	560
						4SB-1 (0-2')	550
						9SB-4 (10-15')	550
						DPT-12 (0-4')	530
						DPT-15(2-4')	530
						DPT-22(2-4')	520
						4HA-2 (0-1')	500
						DPT-26(4-6')	500
						4HA-2 (2-3')	470
						4SB-1 (4-6')	360
						9SB-7 (10-15')	360
						9SB-12 (5-10')	320
						DPT-17/TW-5(2-4')	320
						9SB-22 (10-12')	270
						DPT-10 (0-4')	270
						DPT-15(4-6')	260
						DPT-25(2-4')	260
						DPT-11 (0-4')	250
						DPT-4 (0-4')	250
						DPT-37(4-8')	240
						DPT-8 (0-4')	240

NA - not applicable

Table 4
Risk-Based Concentrations for Chemicals of Potential Concern (COPCs) in Soil and Locations Exceeding Risk-Based Concentrations (RBCs)
Cedar Chemical Site

Chemical	Industrial Worker (mg/kg)	Construction Worker (mg/kg)	Vapor Intrusion Pathway (mg/kg)	Most Protective RBC (mg/kg)	Basis for More Protective RBC	Soil Locations Exceeding RBC	Concentration in sample (mg/kg)
beta-Hexachlorocycolhexane (beta-BHC)	9.58	91	NA	9.58	Excess lifetime cancer risk of 1 x 10^{-5} for industrial worker	None	NA
gamma-Hexachloro-cyclohexane (gamma-BHC)	20.6	173	6.6	6.6	Excess lifetime cancer risk of 1 x 10^{-5} for vapor intrusion	DPT-21(2-4')	45
Propanil	12,300	4,765	NA	4,765	Hazard quotient of 1 for construction worker	None	NA
Toxaphene	15.7	149	NA	15.7	Excess lifetime cancer risk of 1 x 10^{-5} for industrial worker	None	NA

NA - not applicable

Table 5
Perched Zone Groundwater
Risk Based Concentrations for Volatile Chemicals of Potential Concern (COPCs) Based on Vapor Intrusion into an On-Site Building
Cedar Chemical Site

Chemical	Risk-Based Concentration (ug/L)	Basis for Risk Based Concentration
Acetone	*>solubility limit (1,000,000,000 ug/L)	Solubility limit
Aldrin	>solubility limit (17 ug/L)	Solubility limit
2-Butanone (Methyl ethyl ketone)	179,200,000	Hazard quotient of 1
Chlorobenzene	>solubility limit (472,000 ug/L)	Solubility limit
Chloroform	8,940	Excess lifetime cancer risk of 1 x 10^{-5}
1,2-Dichlorobenzene	>solubility limit (156,000 ug/L)	Solubility limit
1,4-Dichlorobenzene	34,800	Excess lifetime cancer risk of 1 x 10^{-5}
1,2-Dichloroethane	14,840	Excess lifetime cancer risk of 1 x 10^{-5}
Dieldrin	>solubility limit (195 ug/L)	Solubility limit
Ethylbenzene	72,000	Hazard quotient of 1
gamma- Hexachlorocyclohexane (g-BHC or Lindane	>solubility limit (7300 ug/L)	Solubility limit
Methoxychlor	>solubility limit (100 ug/L)	Solubility limit
4-Methyl 2-pentanone (Methyl isobutyl ketone)	>solubility limit (19,000,000 ug/L)	Solubility limit
Methylene chloride	534,000	Excess lifetime cancer risk of 1 x 10^{-5}
Toluene	>solubility limit (526,000 ug/L)	Solubility limit
m- and p-Xylenes	>solubility limit (161,000 ug/L)	Solubility limit

*calculated risk-based concentration exceeds water solubility limit; water solubility in parenthesis

Table 6
Chemicals of Concern (COCs) in Perched Zone Groundwater
and Locations Exceeding Risk-Based Concentrations (RBCs)
Cedar Chemical Site

Chemical of Concern	Vapor Intrusion Risk-Based Concentration (ug/L)	Locations Sampled in 2008 Exceeding Risk-Based Concentration	Maximum Location Concentration (ug/L)
Chloroform	8,940	TW-4	13,000
1,2-Dichloroethane	14,840	TW-10	730,000
		MW-18	120,000
		TW-3	37,000

ATTACHMENT A

CALCULATION OF RISK-BASED CONCENTRATIONS OF CHEMICALS IN SOIL

DIRECT CONTACT SOIL EXPOSURE PATHWAY

Risk-based concentrations (RBCs) for the chemicals of potential concern (COPC) in 0 to 10 feet bgs soils were calculated for the long-term on-site worker (assumed to work outside) and the construction worker. The equations in Figure 1 (taken from USEPA guidance; USEPA, 2009) were used to calculate risk-based concentrations in soil for the direct contact pathway. The equations in Figure 1 indicate default inputs for the on-site long-term worker. These equations were also used to calculate RBCs for the construction worker using exposure parameters appropriate for the construction exposure scenario.

Separate equations were used to calculate values for potential carcinogens and noncarcinogens. While potential carcinogens may also have noncarcinogenic effects, the most protective risk-based concentration in soil for each potentially carcinogenic COPC was its cancer-risk based concentration. For this reason, noncancer risk-based RBCs are not shown for potentially carcinogenic COPCs.

USEPA default exposure assumptions were used for nearly all calculations. Inputs used to calculate RBCs for the long-term worker and the construction worker are summarized in Table 1. Chemical-specific toxicity factors and absorption factors are presented in Table 2.

Due to the relatively short duration of exposure (one year), subchronic reference concentrations (RfCs) and oral reference doses (RfDs) are applicable for calculating RBCs for the construction worker. When available, subchronic RfCs and RfDs are used. In the absence of subchronic values, chronic RfCs and RfDs are used to calculate RBCs.

Of the 9 COPCs identified in 0 to 10 feet bgs soils, 1,2-dichloroethane is considered volatile. For this reason, it is necessary to calculate a volatilization factor for soil (VFs) which relates the concentration in soil to the concentration that will result in outdoor air. Site-specific VFs were calculated for 1,2-dichloroethane using meteorological data from the closest location available (Little Rock) and assume that up to 40 acres of the property may be affected.

Several of the terms used in the calculation of the VFs are chemical-specific; they were derived from physical and chemical information obtained from the USEPA's *Soil Screening Guidance: Technical Background Document* (USEPA, 1996). Information regarding constant variables was obtained from Appendix D of the USEPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (2002). The closest city for which information was available was Little Rock, Arkansas.

The equations and inputs presented in Figure 2 were used to calculate VFs for the volatile chemicals of concern for the long-term worker and construction worker.

References

CalEPA 2005. Human Health Risk Assessment (HHRA) Note Number 1: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Military Facilities. California Environmental Protection Agency. California Department of Toxic Substances (DTSC) and Human and Ecological Risk Division (HERD). 2005b, October.

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USEPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. July 2004. EPA/540/R/99/005

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Figure 1- Equations for Calculation of Risk-Based Concentrations (RBC)in Soil for Workers Directly Contacting Soil

Noncancer Risk-Based RBCs

- incidental ingestion of soil,

$$SL_{w\text{-}sol\text{-}nc\text{-}ing}\,(mg/kg)=\frac{THQ\times AT_{ow}\left(\frac{365\text{ days}}{\text{year}}\times ED_{ow}\,(25\text{ years})\right)\times BW_{ow}\,(70\text{ Kg})}{EF_{iw}\left(250\,\frac{\text{days}}{\text{year}}\right)\times ED_{ow}\,(25\text{ years})\times\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)}\times IR_{ow}\left(100\,\frac{mg}{day}\right)\times\left(\frac{10^{-6}\text{ Kg}}{1\text{ mg}}\right)}$$

- inhalation of particulates emitted from soil,

$$SL_{w\text{-}sol\text{-}nc\text{-}inh}\,(mg/kg)=\frac{THQ\times AT_{ow}\left(\frac{365\text{ days}}{\text{year}}\times ED_{ow}\,(25\text{ years})\right)}{EF_{iw}\left(250\,\frac{\text{days}}{\text{year}}\right)\times ED_{ow}\,(25\text{ years})\times ET_{ws}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times\frac{1}{RfC\left(\frac{mg}{m^3}\right)}\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}$$

- dermal exposure,

$$SL_{w\text{-}sol\text{-}nc\text{-}der}\,(mg/kg)=\frac{THQ\times AT_{ow}\left(\frac{365\text{ days}}{\text{year}}\times ED_{ow}\,(25\text{ years})\right)\times BW_{ow}\,(70\text{ Kg})}{EF_{iw}\left(250\,\frac{\text{days}}{\text{year}}\right)\times ED_{ow}\,(25\text{ years})\times\left(\frac{1}{RfD_o\left(\frac{mg}{kg\text{-}day}\right)\times GIABS}\right)\times SA_{ow}\left(\frac{3300\text{ cm}^2}{\text{day}}\right)\times AF_{ow}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right)\times ABS_d\times\left(\frac{10^{-6}\text{ Kg}}{1\text{ mg}}\right)}$$

- Total.

$$SL_{w\text{-}sol\text{-}nc\text{-}tot}\,(mg/kg)=\frac{1}{\frac{1}{SL_{w\text{-}sol\text{-}nc\text{-}ing}}+\frac{1}{SL_{w\text{-}sol\text{-}nc\text{-}der}}+\frac{1}{SL_{w\text{-}sol\text{-}nc\text{-}inh}}}$$

Cancer Risk-Based RBCs

- incidental ingestion of soil,

$$SL_{w\text{-}sol\text{-}ca\text{-}ing}\,(mg/kg)=\frac{TR\times AT_{ow}\left(\frac{365\text{ days}}{\text{year}}\times LT\,(70\text{ years})\right)\times BW_{ow}\,(70\text{ Kg})}{EF_{iw}\left(250\,\frac{\text{days}}{\text{year}}\right)\times ED_{ow}\,(25\text{ years})\times CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}\times IR_{ow}\left(100\,\frac{mg}{day}\right)\times\left(\frac{10^{-6}\text{ Kg}}{1\text{ mg}}\right)}$$

- inhalation of particulates emitted from soil,

$$SL_{w\text{-}sol\text{-}ca\text{-}inh}\,(mg/kg)=\frac{TR\times AT_{ow}\left(\frac{365\text{ days}}{\text{year}}\times LT\,(70\text{ years})\right)}{EF_{iw}\left(250\,\frac{\text{days}}{\text{year}}\right)\times ED_{ow}\,(25\text{ years})\times ET_{ws}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times IUR\left(\frac{\mu g}{m^3}\right)^{-1}\times\left(\frac{1000\,\mu g}{mg}\right)\times\left(\frac{1}{VF_s\left(\frac{m^3}{kg}\right)}+\frac{1}{PEF_w\left(\frac{m^3}{kg}\right)}\right)}$$

- dermal exposure,

$$SL_{w\text{-}sol\text{-}ca\text{-}der}\,(mg/kg)=\frac{TR\times AT_{ow}\left(\frac{365\text{ days}}{\text{year}}\times LT\,(70\text{ years})\right)\times BW_{ow}\,(70\text{ Kg})}{EF_{iw}\left(250\,\frac{\text{days}}{\text{year}}\right)\times ED_{ow}\,(25\text{ years})\times\left(\frac{CSF_o\left(\frac{mg}{kg\text{-}day}\right)^{-1}}{GIABS}\right)\times SA_{ow}\left(\frac{3300\text{ cm}^2}{\text{day}}\right)\times AF_{ow}\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right)\times ABS_d\times\left(\frac{10^{-6}\text{ Kg}}{1\text{ mg}}\right)}$$

- Total.

$$SL_{w\text{-}sol\text{-}ca\text{-}tot}\,(mg/kg)=\frac{1}{\frac{1}{SL_{w\text{-}sol\text{-}ca\text{-}ing}}+\frac{1}{SL_{w\text{-}sol\text{-}ca\text{-}der}}+\frac{1}{SL_{w\text{-}sol\text{-}ca\text{-}inh}}}$$

Figure 2- Calculation of Soil Volatilization Factors (VFs)

$$VF=\frac{\frac{Q}{C_w}\times(3.14\times D_A\times T)^{\frac{1}{2}}\times 10^{-4}\left(m^2/cm^2\right)}{2\times\rho_b\times D_A}$$

where

$$\frac{Q}{C_w}=A\times\exp\left[\frac{(\ln A_s-B)^2}{C}\right]\text{ and}$$

$$D_A=\frac{\left[\left(\theta_a^{10/3}\times D_{ia}\times H'+\theta_w^{10/3}\times D_{iw}\right)/n^2\right]}{\rho_b\times K_d+\theta_w+\theta_a\times H'}$$

Where:

Variable	Definition	Long-Term Worker	Construction Worker
Q/C_w	Site-specific dispersion factor which is the inverse of the ratio of the geometric mean air concentration to the emission flux at the center of the source or at the boundary of the source (g/m^2-sec per kg/m^3)	35.7	6.80
A	Constants based on air dispersion modeling for specific climate zones (dimensionless)	12.5	2.454
B		18.45	17.57
C		210.5	189
A_s	Area of extent of site soil contamination (acres)	40	
K_d	Soil water partition coefficient (cm^3/g)	Chemical specific; calculated as $K_d = K_{oc} \times f_{oc}$; K_{oc} for 1,2-dichloroethane and ethylbenzene presented in Table 2; foc is assumed to be 0.006 (USEPA, 2009)	
DA	Apparent diffusivity (cm^2/s)	Chemical-specific; Refer to Table 2	
$ø_a$	Air filled porosity (L_{air}/L_{soil})	0.284 (USEPA, 2009)	
Di_a	Diffusivity in air (cm^2/sec)	Chemical-specific; Refer to Table 2	
H'	Henry's Law Constant (dimensionless)	Chemical-specific; Refer to Table 2	
$ø_w$	Water filled soil porosity (Lwater/Lsoil)	0.15 (USEPA, 2009)	
D_{iw}	Diffusivity in water (cm2/sec)	Chemical-specific; Refer to Table 2	
n	Total soil porosity (Lpore/Lsoil) $(1-(\rho_d/\rho_s)$	0.434 (USEPA, 2009)	
ρs	Soil particle density (g/cm^3)	2.65 (USEPA, 2009)	
ρ_b	Dry soil bulk density (g/cm^3)	1.5 (USEPA, 2009)	
K_d	Soil water partition coefficient (cm^3/g)	Chemical-specific; Refer to Table 2	
D_A	Apparent diffusivity (cm^2/s)	Chemical-specific; Refer to Table 3	
$ø_a$	Air filled porosity (Lair/Lsoil)	0.284	
D_{ia}	Diffusivity in air (cm^2/sec)	Chemical-specific; Refer to Table 3	
H'	Henry's Law Constant (dimensionless)	Chemical-specific; Refer to Table 3	
$ø_w$	Water filled soil porosity (L_{water}/L_{soil})	0.15	

Variable	Definition	Long-Term Worker	Construction Worker
D_{iw}	Diffusivity in water (cm2/sec)	Chemical-specific; Refer to Table 3	
n	Total soil porosity (Lpore/Lsoil) (1-(ρd/ρs)	0.434	
ρ_s	Soil particle density (g/cm3)	2.65	
ρ_d	Dry soil bulk density (g/cm3)	1.5	
T	Exposure interval (seconds) [equal to the exposure duration expressed in second]	9.50E+08	3.154E+07

Table 1- Equation Inputs

Parameter	Description	On-site Worker (long term worker)	Construction Worker	Reference
ABSd	Dermal absorption fraction (unitless)	Contaminant-specific; see Table 2	Contaminant-specific; see Table 2	USEPA, 2004
AFow	Soil adherence to skin (mg/cm^2)	0.2	0.3	USEPA, 2002
ATow	Averaging time (days/exposure period)	25,550 days (cancer risk); 9125 days (noncancer risk)	25,550 days (cancer risk); 365 days (noncancer risk)	USEPA, 2002
BWow	Body weight (kg)	70	70	USEPA, 2002
CSFo	Oral slope factor (kg-day/mg)	Contaminant-specific; see Table 2	Contaminant-specific; see Table 2	IRIS, 2009; USEPA, 2009
EDow	Exposure Duration (yr)	25	1	USEPA, 2002
EFiw	Exposure Frequency (days/yr)	250	250	USEPA, 2002
ETws	Exposure Time-air (hr/hr)	0.33	0.33	8 hours per 24 hour day
GIABS	Fraction of contaminant absorbed in gastrointestinal tract (unitless)	1 (for all contaminants)	1 (for all contaminants)	U.S. EPA 2004
IRow	Soil ingestion rate (mg/day)	100	330	USEPA, 2002
IUR	Inhalation unit cancer risk (m^3/ug)	Contaminant-specific; see Table 2	Contaminant-specific; see Table 2	IRIS, 2009; USEPA, 2009
PEFw	Soil particle emission factor (m^3/kg)	1.40E+09	1.00E+06	USEPA, 2009; CalEPA, 2005
RfC	Reference concentration (mg/m^3)	Contaminant-specific; see Table 2	Contaminant-specific; see Table 2	IRIS, 2009; USEPA, 2009
RfDo	Oral reference dose (mg/kg/day)	Contaminant-specific; see Table 2	Contaminant-specific; see Table 2	IRIS, 2009; USEPA, 2009
SAow	Skin surface area exposed to soil (cm^2)	3300	3300	U.S. EPA 2002
THQ	Target Hazard Quotient	1	1	--
TR	Target Cancer Risk	1.00E-05	1.00E-05	--
VFs	Soil volatilization factor (m^3/kg)	Contaminant-specific; see Table 2	Contaminant-specific; see Table 2	

Table 2
Chemical-Specific Inputs Used to Calculate Risk-Based Concentrations for Soil

Chemical	Chronic RfC (mg/m^3)	Chronic RfD (mg/kg/day)	Subchronic RfC (mg/m^3)	Subchronic RfD (mg/kg/day)	IUR (m^3/ug)	SF_o (mg/kg/day)$^{-1}$	ABS unitless	Considered volatile by USEPA?	D_A (cm^2/s)	D_{ia} (cm^2/s)	D_{iw} (cm^2/s)	H' dimension-less	K_{oc} (cm^3/g)	K_d (cm^3/g)	VFs m^3/kg
Aldrin	not avail	3.0E-05	not avail	not avail	4.9E-03	1.7E+01	0.1	no	not appl	not appl	not appl	not appl	not appl	not appl	not appl
Chlordane	7.0E-04	5.0E-04	not avail	not avail	1.0E-04	3.5E-01	0.04	no	not appl	not appl	not appl	not appl	not appl	not appl	not appl
1,2-Dichloroethane	2.4E+00	2.0E-02	not avail	not avail	2.6E-05	9.1E-02	not appl	YES	5.94E-04	0.086	1.10E-05	4.80E-02	4.38E+01	2.63E-01	2630 (long-term worker) 92.5 (const. worker)
Dieldrin	not avail	5.0E-05	not avail	1.00E-04	4.6E-03	1.6E+01	0.1	no	not appl	not appl	not appl	not appl	not appl	not appl	not appl
Dinoseb	not avail	1.0E-03	not avail	not avail	not avail	not avail	0.1	no	not appl	not appl	not appl	not appl	not appl	not appl	not appl
Hexachlorocyclohexane-gamma (gamma-BHC)	not avail	not avail	not avail	not avail	5.3E-04	1.8E+00	0.1	no	not appl	not appl	not appl	not appl	not appl	not appl	not appl
Hexachlorocyclohexane-gamma (gamma-BHC)	not avail	5.0E-03	not avail	not avail	3.1E-04	1.1E+00	0.04	no	not appl	not appl	not appl	not appl	not appl	not appl	not appl
Propanil	not avail	2.0E-02	not avail	not avail	not avail	not avail	0.1	no	not appl	not appl	not appl	not appl	not appl	not appl	not appl
Toxaphene	not avail	not avail	not avail	1.00E-03	3.2E-04	1.1E+00	0.1	no	not appl	not appl	not appl	not appl	not appl	not appl	not appl

not avail- USEPA toxicity value not available
not appl- not applicable; chemical not volatile
RfC = Reference concentration
RfD = Reference dose
IUR = Inhalation Unit Risk
SFo = Oral slope factor
ABS = Dermal absorption factor
D_A = Apparent diffusivity
D_{ia} = Diffusivity in air
D_{iw} = Diffusitity in water
H' = Henry's Law Constant
K_{oc} = Soil organic carbon partition coefficient
K_d = Soil water partition coefficient

ATTACHMENT B

CALCULATION OF RISK-BASED CONCENTRATIONS OF CHEMICALS IN ON-SITE SOIL FOR THE VAPOR INTRUSION PATHWAY

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemica
309002		Aldrin

MORE ↓

ENTER Average soil temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
25	15	15	518	15	0	0	SIC		

Totals must add up to value of L_t (cell G28)

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
Lookup Soil Parameters					Lookup Soil Parameters					Lookup Soil Parameters				
SIC	1.38	0.481	0.216	0.002	C	1.43	0.459	0.215	0.002	C	1.43	0.459	0.215	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based soil concentration.

END

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
4.37E+04	NA	4.37E+04	8.33E+04	4.37E+04

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
MESSAGE: Risk/HQ or risk-based soil concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemica
57749		Chlordane

MORE ↓

ENTER Average soil temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
25	15	15	518	15	0	0	SIC		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
SIC	1.38	0.481	0.216	0.002	C	1.43	0.459	0.215	0.002	C	1.43	0.459	0.215	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based soil concentration.

END

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
3.67E+05	9.19E+05	3.67E+05	1.34E+04	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemica
107062		1,2-Dichloroethane

MORE ↓

ENTER Average soil temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)		ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
				Totals must add up to value of L_t (cell G28)				OR	
25	15	15	518	15	0	0	SIC		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
Lookup Soil Parameters					Lookup Soil Parameters					Lookup Soil Parameters				
SIC	1.38	0.481	0.216	0.002	C	1.43	0.459	0.215	0.002	C	1.43	0.459	0.215	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1
				Used to calculate risk-based soil concentration.	

END

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
1.77E+02	NA	1.77E+02	1.70E+06	1.77E+02

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemica
60571		Dieldrin

MORE ↓

ENTER Average soil temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
25	15	15	518	15	0	0	SIC		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
SIC	1.38	0.481	0.216	0.002	C	1.43	0.459	0.215	0.002	C	1.43	0.459	0.215	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based soil concentration.

END

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
4.58E+03	NA	4.58E+03	8.38E+03	4.58E+03

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
MESSAGE: Risk/HQ or risk-based soil concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES | X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES |

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
58899		gamma-HCH (Lindane)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
25	15	15	518	15	0	0	SIC		

Totals must add up to value of L_t (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
SIC	1.38	0.481	0.216	0.002	C	1.43	0.459	0.215	0.002	C	1.43	0.459	0.215	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based soil concentration.

END

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (μg/kg)	Indoor exposure soil conc., noncarcinogen (μg/kg)	Risk-based indoor exposure soil conc., (μg/kg)	Soil saturation conc., C_{sat} (μg/kg)	Final indoor exposure soil conc., (μg/kg)
3.30E+03	NA	3.30E+03	1.68E+04	3.30E+03

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
MESSAGE: Risk/HQ or risk-based soil concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

ATTACHMENT C

CALCULATION OF RISK-BASED CONCENTRATIONS FOR CHEMICALS IN ON-SITE PERCHED ZONE GROUNDWATER VAPOR INTRUSION PATHWAY

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
67641	5.00E+01	Acetone

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	5.89E+08	5.89E+08	1.00E+09	5.89E+08

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
309002	5.00E+01	Aldrin

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

Lookup Soil Parameters | Lookup Soil Parameters | Lookup Soil Parameters

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
1.75E+02	3.22E+03	1.75E+02	1.70E+01	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater co 309002
MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
78933	5.00E+01	Methylethylketone (2-butanone)

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	8.96E+07	8.96E+07	2.23E+08	8.96E+07

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

309002

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES | X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES |

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
108907	5.00E+01	Chlorobenzene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	2.50E+05	2.50E+05	4.72E+05	2.50E+05

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
67663	5.00E+01	Chloroform

MORE ↓

Totals must add up to value of L_{WT} (cell G28)

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
4.47E+03	3.60E+05	4.47E+03	7.92E+06	4.47E+03

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
95501	5.00E+01	1,2-Dichlorobenzene

MORE ↓

Totals must add up to value of L_{WT} (cell G28)

ENTER Average soil/ groundwater temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

MORE ↓

ENTER Stratum A SCS soil type Lookup Soil Parameters	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type Lookup Soil Parameters	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type Lookup Soil Parameters	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	1.51E+06	1.51E+06	1.56E+05	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES | X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES |

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
107062	5.00E+01	1,2-Dichloroethane

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
7.42E+03	NA	7.42E+03	8.52E+06	7.42E+03

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
60571	5.00E+01	Dieldrin

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
8.45E+02	2.43E+04	8.45E+02	1.95E+02	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.
MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
100414	5.00E+01	Ethylbenzene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

MORE ↓

ENTER Stratum A SCS soil type Lookup Soil Parameters	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type Lookup Soil Parameters	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type Lookup Soil Parameters	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
3.60E+04	3.21E+06	3.60E+04	1.69E+05	3.60E+04

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES | X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES |

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
58899	5.00E+01	gamma-HCH (Lindane)

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
8.23E+03	1.14E+05	8.23E+03	7.30E+03	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.
MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
108101	5.00E+01	Methylisobutylketone (4-methyl-2-

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	4.43E+07	4.43E+07	1.90E+07	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.

SCROLL DOWN TO "END"

END

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
75092	5.00E+01	Methylene chloride

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
2.67E+05	4.49E+06	2.67E+05	1.30E+07	2.67E+05

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
108883	5.00E+01	Toluene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER (Totals must add up to value of L_{WT} (cell G28)) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

MORE ↓

ENTER Stratum A SCS soil type Lookup Soil Parameters	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type Lookup Soil Parameters	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type Lookup Soil Parameters	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	1.54E+07	1.54E+07	5.26E+05	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
108383	5.00E+01	m-Xylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17	200	549	549	0	0	A	SIC	SIC		0.00E+00

Totals must add up to value of L_{WT} (cell G28) (applies to thickness of soil strata A, B, C)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SIC	1.38	0.481	0.216	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	2440	2440	366	0.1	1	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (μg/L)	Indoor exposure groundwater conc., noncarcinogen (μg/L)	Risk-based indoor exposure groundwater conc., (μg/L)	Pure component water solubility, S (μg/L)	Final indoor exposure groundwater conc., (μg/L)
NA	3.55E+05	3.55E+05	1.61E+05	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.

SCROLL DOWN TO "END"

END

APPENDIX B

Breakdown of Estimated Costs for Specific Remedy Elements

REMEDIAL DESIGN AND WORKPLANS					Total:	$587,412
1. Soil Remedy						$185,480
Assume	40	Principal	$205	per hour		$8,200
Assume	220	Senior I	$160	per hour		$35,200
Assume	380	Project II	$156	per hour		$59,280
Assume	360	Staff II	$99	per hour		$35,640
Assume	400	CAD	$76	per hour		$30,400
Assume	80	Clerical Support	$72	per hour		$5,760
Assume	10	Copying/Reproduction	$1,000	per copy		$10,000
Assume	10	Shipping	$100	per copy		$1,000
2. Perched Zone Remedy						$130,385
Assume	40	Principal	$205	per hour		$8,200
Assume	150	Senior I	$160	per hour		$24,000
Assume	250	Project II	$156	per hour		$39,000
Assume	275	Staff II	$99	per hour		$27,225
Assume	200	CAD	$76	per hour		$15,200
Assume	80	Clerical Support	$72	per hour		$5,760
Assume	10	Copying/Reproduction	$1,000	per copy		$10,000
Assume	10	Shipping	$100	per copy		$1,000
3. Alluvial Aquifer						$173,645
Assume	45	Principal	$205	per hour		$9,225
Assume	225	Senior I	$160	per hour		$36,000
Assume	275	Project II	$156	per hour		$42,900
Assume	280	Staff II	$99	per hour		$27,720
Assume	540	CAD	$76	per hour		$41,040
Assume	80	Clerical Support	$72	per hour		$5,760
Assume	10	Copying/Reproduction	$1,000	per copy		$10,000
Assume	10	Shipping	$100	per copy		$1,000
4. Contingency						$97,902
Assume	1	Contingency	20%			$97,902

Note: AMEC Labor and Expense Pricing from 2009 Cedar Chemical Pricing Schedule

SOIL REMEDY ALTERNATIVE S1: EXPOSURE CONTROLS				Total:	$3,009,573
1. GeoTextile Equipment and Materials					$325,000
Assume	20	days to complete			
Assume	460 Loads	clean fill	$8,280	per load	$207,000
Assume	5	geotextile	$20,000	per acre	$100,000
Assume	20	Equipment	$400	per day	$8,000
Assume	1	Geotechnical Testing	$10,000	ea	$10,000
2. Geotextile Subcontract Labor+Expenses					$15,000
Assume	1	subcontractor labor + per diem (2 techs *20 day)	$15,000		$15,000
3. Paving					$1,710,000
Assume	380,000	sqft at	$4.50	per sqft	$1,710,000
4. AMEC Project Oversight					$176,040
Assume	3	months Office Trailer	$500	per month	$1,500
Assume	120	days Per Diem/Lodging	$130	per day	$15,600
Assume	1440	hours Senior Technician	$86	per hour	$123,840
Assume	6	airfare/parking	$650	per trip	$3,900
Assume	120	days Per Diem/Lodging/Vehicle at	$260	per day	$31,200
5. Project Management & Reporting					$261,104
Assume	1	Report	$35,000		$35,000
Assume	1	AMEC Project management at 10% of all other costs			$226,104
6. Contingency					$497,429
Assume	1	Contingency	20%		$497,429
7. Institutional Controls Implementation					
Assume $25,000 to implement the IC Process.					$25,000.00

Note: Paving Pricing from Alamo 1, Geotextile pricing from USES

* Footage assumes a 20% coverage by existing concrete pads

AMEC Labor and Expense pricing from Cedar Chemical 2009 Pricing Schedule.

The expected duration of the above effort is three months.

SOIL REMEDY ALTERNATIVE S2: IN SITU STABILIZATION, AREA-WIDE APPROACH					Total:	$8,725,091
1. Mobilization						$18,018
Assume	32	D6 Dozer (4)	$86.63	per hour		$2,772
Assume	32	compactors (4)	$86.63	per hour		$2,772
Assume	24	Water Truck (4)	$86.63	per hour		$2,079
Assume	24	Dump Truck (4)	$86.63	per hour		$2,079
Assume	32	924 loader (4)	$86.63	per hour		$2,772
Assume	64	210 trackhoe (8)	$86.63	per hour		$5,544
2. Foundation and Pavement Removal						$770,964
Assume	385,482	sqft of foundation and pavement removal	$2.00	per sqft		$770,964
3. Excavation (50 cubic yards per hour)						$1,384,662
Assume	5256	Trackhoes	$165.31	per hour		$868,837
Assume	1314	Contractor Supervisor	$66.00	per hour		$86,723
Assume	5256	Dump Truck	$81.64	per hour		$429,102
4. Stabilization						$3,861,997
Assume	43,584	Fly ash	$32.24	per ton delivered		$1,405,150
Assume	5256	Trackhoes	$165.31	per hour		$868,837
Assume	2628	Dozers	$127.89	per hour		$336,092
Assume	2628	Compactors	$87.65	per hour		$230,335
Assume	2628	Loader @ Stock Pile	$101.63	per hour		$267,073
Assume	2628	Water Wagon	$81.64	per hour		$214,551
Assume	2628	Dump Truck	$102.72	per hour		$269,935
Assume	3285	Compaction Tests	$45.00	per hour		$147,823
Assume	657	Contractor Supervisor	$66.00	per hour		$43,361
Assume	2628	Labor	$30.00	per hour		$78,839
5. Confirmation Sampling						$329,990
Assume	142	samples (16 samples per acre)				
Assume	142	SPLP Confirmation sample	$845	per sample		$119,990
Assume	420	days rental equipment at		per day	$500	$210,000
6. AMEC Field Oversight						$279,374
Assume	14	months Office Trailer at	$500.00	per month		$7,000
Assume	320	days Per Diem/Lodging/Truck Rental at	$260.00	per day		$32,044
Assume	3204	hours AMEC Field Supervisor at	$86.00	per hour		$240,330
7. Project Management & Reporting						$625,904
Assume	1	Report	$35,000	Lump Sum		$35,000
Assume	1	AMEC Project management at 10% of all other costs				$590,904
8. Contingency						$1,454,182
Assume	1	Contingency	20%			$1,454,182

Note: Pricing based on work by Russell Duke of USA Environment
Assumes 15% fly ash addition by weight
The expected duration of the above effort is fourteen months.

SOIL REMEDY ALTERNATIVE S2: IN SITU STABILIZATION, FOCUSED APPROACH					Total:	$2,144,255
1. Mobilization						$18,018
Assume	32	D6 Dozer (4)	$86.63	per hour		$2,772
Assume	32	compactors (4)	$86.63	per hour		$2,772
Assume	24	Water Truck (4)	$86.63	per hour		$2,079
Assume	24	Dump Truck (4)	$86.63	per hour		$2,079
Assume	32	924 loader (4)	$86.63	per hour		$2,772
Assume	64	210 trackhoe (8)	$86.63	per hour		$5,544
2. Foundation and Pavement Removal						$175,784
Assume	87,892	sqft of foundation and pavement removal	$2.00	per sqft		$175,784
3. Excavation (50 cubic yards per hour)						$323,102
Assume	1226	Trackhoes	$165.31	per hour		$202,738
Assume	307	Contractor Supervisor	$66.00	per hour		$20,236
Assume	1226	Dump Truck	$81.64	per hour		$100,128
4. Stabilization						$901,173
Assume	10,170	Fly ash	$32.24	per ton delivered		$327,883
Assume	1226	Trackhoes	$165.31	per hour		$202,738
Assume	613	Dozers	$127.89	per hour		$78,425
Assume	613	Compactors	$87.65	per hour		$53,747
Assume	613	Loader @ Stock Pile	$101.63	per hour		$62,320
Assume	613	Water Wagon	$81.64	per hour		$50,064
Assume	613	Dump Truck	$102.72	per hour		$62,988
Assume	767	Compaction Tests	$45.00	per hour		$34,494
Assume	153	Contractor Supervisor	$66.00	per hour		$10,118
Assume	613	Labor	$30.00	per hour		$18,397
5. Confirmation Sampling						$94,645
Assume	41	samples (16 samples per acre)				
Assume	41	SPLP Confirmation sample	$845	per sample		$34,645
Assume	120	days rental equipment at		per day	$500	$60,000
6. AMEC Excavation Contractor Field Oversight						$76,714
Assume	4	months Office Trailer at	$500.00	per month		$2,000
Assume	88	days Per Diem/Lodging/Truck Rental at	$260.00	per day		$8,790
Assume	879	hours AMEC Field Supervisor at	$86.00	per hour		$65,924
7. Project Management & Reporting						$197,444
Assume	1	Report	$35,000	Lump Sum		$35,000
Assume	1	AMEC Project management at 10% of all other costs				$162,444
8. Contingency						$357,376
Assume	1	Contingency	20%			$357,376

Note: Pricing based on work by Russell Duke of USA Environment
Assumes 15% fly ash addition by weight
The expected duration of the above effort is four months.

SOIL REMEDY ALTERNATIVE S3: EXCAVATION WITH OFF-SITE DISPOSAL AS SOLID WASTE, AREA-WIDE APPROACH				Total:	$50,034,669
1. Mobilization					$18,018
Assume	32	D6 Dozer (4)	$86.63	per hour	$2,772
Assume	32	compactors (4)	$86.63	per hour	$2,772
Assume	24	Water Truck (4)	$86.63	per hour	$2,079
Assume	24	Dump Truck (4)	$86.63	per hour	$2,079
Assume	32	924 loader (4)	$86.63	per hour	$2,772
Assume	64	210 trackhoe (8)	$86.63	per hour	$5,544
2. Foundation and Pavement Removal					$770,964
Assume	385,482	sqft of foundation and pavement removal	$2.00	per sqft	$770,964
3. Excavation (50 cubic yards per hour)					$1,384,662
Assume	5256	Trackhoes	$165.31	per hour	$868,837
Assume	1314	Contractor Supervisor	$66.00	per hour	$86,723
Assume	5256	Dump Truck	$81.64	per hour	$429,102
4. Backfill					$5,205,069
Assume	341,635	cubic truck yards of backfill at	$10.59	per cy	$3,617,059
Assume	2628	Dozers	$127.89	per hour	$336,092
Assume	2628	Compactors	$87.65	per hour	$230,335
Assume	2628	Loader @ Stock Pile	$101.63	per hour	$267,073
Assume	2628	Water Wagon	$81.64	per hour	$214,551
Assume	2628	Dump Truck	$102.72	per hour	$269,935
Assume	3285	Compaction Tests	$45.00	per hour	$147,823
Assume	657	Contractor Supervisor	$66.00	per hour	$43,361
Assume	2628	Contractor Labor	$30.00	per hour	$78,839
5. Waste Transportation and Disposal,					$29,912,538
Assume	28,470	transported loads of soil	$385.00	per load	$10,960,786
Assume	261,504	tons of non hazardous soil disposal	$38.00	per ton	$9,937,168
Assume	29,056	tons of hazardous soil disposal	$132.00	per ton	$3,835,398
Assume	6,833	waste profile samples (50yd/sample)	$758.00	per sample	$5,179,185
6. Confirmation Sampling					$346,320
Assume	213	samples (24 samples per acre)			
Assume	213	Confirmation sample	$640	per sample	$136,320
Assume	420	days rental equipment at	$500	per day	$210,000
7. AMEC Excavation & Contractor Field Oversight					$279,374
Assume	14	months Rental Office Trailer at	$500.00	per month	$7,000
Assume	320	days Per Diem/Lodging/Truck Rental at	$260.00	per day	$32,044
Assume	3204	hours AMEC Field Supervisor at	$86.00	per hour	$240,330
8. Project Management & Reporting					$3,778,612
Assume	1	Report	$35,000	Lump Sum	$35,000
Assume	1	AMEC Project management at 10% of all other costs			$3,743,612
8. Contingency					$8,339,111
Assume	1	Contingency	20%		$8,339,111

Note: Pricing based on work by Russell Duke of USA Environment
Projected volume of soil excavated includes benching at a 1:1 slope
The expected duration of the above effort is fourteen months.

SOIL REMEDY ALTERNATIVE S3: EXCAVATION WITH OFF-SITE DISPOSAL AS SOLID WASTE, FOCUSED APPROACH

Total: $11,891,182

1. Mobilization					$18,018
Assume	32	D6 Dozer (4)	$86.63	per hour	$2,772
Assume	32	compactors (4)	$86.63	per hour	$2,772
Assume	24	Water Truck (4)	$86.63	per hour	$2,079
Assume	24	Dump Truck (4)	$86.63	per hour	$2,079
Assume	32	924 loader (4)	$86.63	per hour	$2,772
Assume	64	210 trackhoe (8)	$86.63	per hour	$5,544
2. Foundation and Pavement Removal					$175,784
Assume	87,892	sqft of foundation and pavement removal	$2.00	per sqft	$175,784
3. Excavation (50 cubic yards per hour)					$323,102
Assume	1226	Trackhoes	$165.31	per hour	$202,738
Assume	307	Contractor Supervisor	$66.00	per hour	$20,236
Assume	1226	Dump Truck	$81.64	per hour	$100,128
4. Backfill					$1,214,571
Assume	79,718	cubic truck yards of backfill at	$10.59	per cy	$844,018
Assume	613	Dozers	$127.89	per hour	$78,425
Assume	613	Compactors	$87.65	per hour	$53,747
Assume	613	Loader @ Stock Pile	$101.63	per hour	$62,320
Assume	613	Water Wagon	$81.64	per hour	$50,064
Assume	613	Dump Truck	$102.72	per hour	$62,988
Assume	767	Compaction Tests	$45.00	per hour	$34,494
Assume	153	Contractor Supervisor	$66.00	per hour	$10,118
Assume	613	Contractor Labor	$30.00	per hour	$18,397
5. Waste Transportation and Disposal,					$6,979,905
Assume	6,643	transported loads of soil	$385.00	per load	$2,557,631
Assume	61,020	tons of non hazardous soil disposal	$38.00	per ton	$2,318,777
Assume	6,780	tons of hazardous soil disposal	$132.00	per ton	$894,966
Assume	1,594	waste profile samples (50yd/sample)	$758.00	per sample	$1,208,531
6. Confirmation Sampling					$196,320
Assume	213	samples (24 samples per acre)			
Assume	213	Confirmation sample	$640	per sample	$136,320
Assume	120	days rental equipment at	$500	per day	$60,000
7. AMEC Excavation & Contractor Field Oversight					$76,714
Assume	4	months Rental Office Trailer at	$500.00	per month	$2,000
Assume	88	days Per Diem/Lodging/Truck Rental at	$260.00	per day	$8,790
Assume	879	hours AMEC Field Supervisor at	$86.00	per hour	$65,924
8. Project Management & Reporting					$924,905
Assume	1	Report	$35,000	Lump Sum	$35,000
Assume	1	AMEC Project management at 10% of all other costs			$889,905
9. Contingency					$1,981,864
Assume	1	Contingency	20%		$1,981,864

Note: Pricing based on work by Russell Duke of USA Environment
Projected volume of soil excavated includes benching at a 1:1 slope
The expected duration of the above effort is four months.

SOIL REMEDY ALTERNATIVE S4: SOIL VAPOR EXTRACTION, AREA-WIDE APPROACH (Capital Costs) Total: $6,150,694

1. Power to Site					$50,000
Assume	$50,000	to drop electrical connection to system, including: • Installation by a qualified electrician; • Installation of main disconnect; • Installation of an electrical meter face.			
2. SVE System Equipment					$900,000
Assume	1	Prewired, skid mounted 10,000 scfm SVE system, including: 2 X 500 Hp PD Blowers 2 X 500 gallon vapor/liquid separator with transfer pump 5,000 gallon holding tank 2 X 5000 lb carbon vessels Control system w/ telemetry			$900,000
3. SVE System Installation					$2,992,632
Assume	640	SVE wells at	$3,215	per well	$2,057,450
Assume	18	truck loads of IDW	$385	per load	$6,930
Assume	24	tons of hazardous IDW	$132	per ton	$3,140
Assume	214	tons of non-hazardous IDW	$38	per ton	$8,135
Assume	117	IDW profile samples	$758	per sample	$88,686
Assume	7,211	feet of trenching at	$30	per linear foot	$216,330
Assume	7,211	feet of piping at	$30	per linear foot	$216,330
Assume	7,211	feet of resurfacing at	$12	per linear foot	$86,532
Assume	640	wellhead fittings at	$400	per well	$256,000
Assume	2,500	sqft concrete pad at	$11	per sqft	$27,500
Assume fencing cost to enclose system of			$3,400		$3,400
Assume	8	TO-14 Analysis at Start-up	$275	per sample	$2,200
Assume	1	Air Emissions Permit	$20,000	lump sum	$20,000
4. Installation Direction and Oversight					$666,984
Assume	3,200	Project Scientist I	$113	per hour	$361,600
Assume	1,200	Senior Technician	$86	per hour	$103,200
Assume	352	hours of travel to/from the site			$37,184
Assume	440	per diem/lodging/truck/fuel	$260	per day	$114,400
Assume	44	airfare and parking costs of	$650	round trip.	$28,600
Assume	88	field supplies cost of	$250	per week	$22,000
5. Project Management & Reporting					$515,962
Assume	1	Installation report & drawings	$50,000	lump sum	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$465,962
6. Contingency					$1,025,116
Assume	1	Contingency	20%		$1,025,116

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
The expected duration of the above effort is nine months.

SOIL REMEDY ALTERNATIVE S4: SOIL VAPOR EXTRACTION, AREA-WIDE APPROACH (Annual Costs)					Total:	$1,412,553
1. Utilities/Carbon						$853,893
Assume	1,200	Total SVE system horsepower				
Assume	8,760	System run-time (hours/year)				
Assume	$0.10	per kilowatt hour		Electrical Total:		$783,893
Assume	4	Carbon Changes at	$17,500	per change:		$70,000
2. Fluid Profiling/Air Emissions Analytical Costs						$4,590
Assume	2	VOC in water analysis	$125	per sample		$250
Assume	2	SVOC in water analysis	$250	per sample		$500
Assume	2	RCRA metals in water analysis	$100	per sample		$200
Assume	2	TPH in water analysis	$60	per sample		$120
Assume	2	RCI in water analysis	$110	per sample		$220
Assume	12	TO-14 analysis	$275	per sample		$3,300
3. System Operation						$172,033
Assume	1	technician at	$86	per hour		
Assume	6	hours of travel to/from the site from Houston, TX	$86	per hour		$516
Assume	32	hours of system inspection, sampling, and maintenance	$88	per hour		$2,752
Assume	5	per diem/lodging/truck/fuel	$260	per day		$1,300
Assume airfare and parking costs of			$650	round trip.		$650
Assume field supplies cost of			$100	per inspection		$100
Assume	12	events at	$5,318	per event		$63,816
Assume	1	10 % of wells to be replaced annually @ 50% cost	$108,217	lump sum		$108,217
4. Fluid Disposal						$27,600
Assume	10,000	gallons of hazardous water disposal	$2.50	per gallon		$25,000
Assume	20	hours of vacuum truck (includes transport)	$95	per hour		$1,900
Assume	2	Truck washout	$350	each		$700
5. Project Management & Reporting						$119,012
Assume	4	System operation report	$3,000	lump sum		$12,000
Assume	1	AMEC Project management at 10% of all other costs				$107,012
6. Contingency						$235,425
Assume	1	Contingency	20%			$235,425

Note: Carbon pricing from Siemens (formerly US Filter)
Analytical costs from ALS Laboratories.
Water analytical for waste profiling

SOIL REMEDY ALTERNATIVE S4: SOIL VAPOR EXTRACTION, AREA-WIDE APPROACH (Decommissioning Costs)				Total:	$950,789
1. System Decommissioning					$442,285
Assume	1	Mob/Demob	$1,000	each	$1,000
Assume	30	Equipment Rental	$350	days	$10,500
Assume	30	Labor (4 man crew, 10 hrs/day)	$1,800	days	$54,000
Assume	30	Total days of contractor per diem (4 man crew)	$130	man/day	$3,900
Assume	13	truck loads of waste	$385	per load	$5,005
Assume	20	tons of hazardous IDW	$132	per ton	$2,640
Assume	180	tons of non-hazardous IDW	$38	per ton	$6,840
Assume	640	Wells plugged and abandoned (est. depth 20 ft)	$560	each	$358,400
2. AMEC Oversight					$56,360
Assume	48	per diem/lodging/truck/fuel	$260	per day	$12,480
Assume	480	hours Senior Technician at	$86	per hour	$41,280
Assume	4	airfare	$650	per trip	$2,600
3. Confirmation Sampling and Reporting					$171,650
Assume	213	samples (24 samples per acre)			
Assume	213	Confirmation sample	$640	per sample	$136,320
Assume	8	days of Geoprobe	$2,500	per day	$20,000
Assume	10	hours per technician/day for	8	days per event	
Assume	8	hours sample shipping at	1	per event	
Assume	12	hours mob for technician at	1	per event	
Assume	100	hours for technician at	$86	per hour	$8,600
Assume	8	per diem/lodging/truck/fuel	$260	per event	$2,080
Assume	1	airfare	$650	per trip	$650
Assume	8	days rental equipment at	$500	per day	$4,000
4. Project Management & Reporting					$122,030
Assume	1	Annual Report	$50,000	per report	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$72,030
5. Contingency					$158,465
Assume	1	Contingency	20%		$158,465

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
The expected duration of the above effort is two months.

SOIL REMEDY ALTERNATIVE S4: SOIL VAPOR EXTRACTION, FOCUSED APPROACH (Capital Costs) Total: $1,431,684

1. Power to Site					$25,000
Assume	$25,000	to drop electrical connection to system, including: • Installation by a qualified electrician; • Installation of main disconnect; • Installation of an electrical meter face.			
2. SVE System Equipment					$225,000
Assume	1	Prewired, skid mounted 10,000 scfm SVE system, including: 2 X 500 Hp PD Blowers 2 X 500 gallon vapor/liquid separator with transfer pump 5,000 gallon holding tank 2 X 5000 lb carbon vessels Control system w/ telemetry			$225,000
3. SVE System Installation					$651,622
Assume	131	SVE wells at	$3,366	per well	$440,910
Assume	4	truck loads of IDW	$385	per load	$1,540
Assume	5	tons of hazardous IDW	$132	per ton	$643
Assume	44	tons of non-hazardous IDW	$38	per ton	$1,665
Assume	24	IDW profile samples	$758	per sample	$18,192
Assume	1,476	feet of trenching at	$30	per linear foot	$44,280
Assume	1,476	feet of piping at	$30	per linear foot	$44,280
Assume	1,476	feet of resurfacing at	$12	per linear foot	$17,712
Assume	131	wellhead fittings at	$400	per well	$52,400
Assume	400	sqft concrete pad at	$11	per sqft	$4,400
Assume fencing cost to enclose system of			$3,400		$3,400
Assume	8	TO-14 Analysis at Start-up	$275	per sample	$2,200
Assume	1	Air Emissions Permit	$20,000	lump sum	$20,000
4. Installation Direction and Oversight					$142,987
Assume	655	Project Scientist I	$113	per hour	$74,015
Assume	295	Senior Technician	$86	per hour	$25,387
Assume	76	hours of travel to/from the site			$7,952
Assume	95	per diem/lodging/truck/fuel	$260	per day	$24,705
Assume	10	airfare and parking costs of	$650	round trip.	$6,176
Assume	19	field supplies cost of	$250	per week	$4,751
5. Project Management & Reporting					$148,461
Assume	1	Installation report & drawings	$40,000	lump sum	$40,000
Assume	1	AMEC Project management at 10% of all other costs			$108,461
6. Contingency					$238,614
Assume	1	Contingency	20%		$238,614

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
The expected duration of the above effort is 5 months.

SOIL REMEDY ALTERNATIVE S4: SOIL VAPOR EXTRACTION, FOCUSED APPROACH (Annual Costs)				Total:	$516,715
1. Utilities/Carbon					$275,298
Assume	400	Total SVE system horsepower			
Assume	8,760	System run-time (hours/year)			
Assume	$0.10	per kilowatt hour		Electrical Total:	$261,298
Assume	4	Carbon Changes at	$3,500	per change:	$14,000
2. Fluid Profiling/Air Emissions Analytical Costs					$4,590
Assume	2	VOC in water analysis	$125	per sample	$250
Assume	2	SVOC in water analysis	$250	per sample	$500
Assume	2	RCRA metals in water analysis	$100	per sample	$200
Assume	2	TPH in water analysis	$60	per sample	$120
Assume	2	RCI in water analysis	$110	per sample	$220
Assume	12	TO-14 analysis	$275	per sample	$3,300
3. System Operation					$86,963
Assume	1	technician at	$86	per hour	
Assume	6	hours of travel to/from the site from Houston, TX	$86	per hour	$516
Assume	32	hours of system inspection, sampling, and maintenance	$88	per hour	$2,752
Assume	5	per diem/lodging/truck/fuel	$260	per day	$1,300
Assume airfare and parking costs of			$650	round trip.	$650
Assume field supplies cost of			$100	per inspection	$100
Assume	12	events at	$5,318	per event	$63,816
Assume	1	10 % of wells to be replaced annually @ 50% cost	$23,147	lump sum	$23,147
4. Fluid Disposal					$12,600
Assume	4,000	gallons of hazardous water disposal	$2.50	per gallon	$10,000
Assume	20	hours of vacuum truck (includes transport)	$95	per hour	$1,900
Assume	2	Truck washout	$350	each	$700
5. Project Management & Reporting					$51,145
Assume	4	System operation report	$3,000	lump sum	$12,000
Assume	1	AMEC Project management at 10% of all other costs			$39,145
6. Contingency					$86,119
Assume	1	Contingency	20%		$86,119

Note: Carbon pricing from Siemens (formerly US Filter)
Analytical costs from ALS Laboratories.
Water analytical for waste profiling

SOIL REMEDY ALTERNATIVE S4: SOIL VAPOR EXTRACTION, FOCUSED APPROACH (Decommissioning Costs)				Total:	$374,499
1. System Decommissioning					$157,245
Assume	1	Mob/Demob	$1,000	each	$1,000
Assume	30	Equipment Rental	$350	days	$10,500
Assume	30	Labor (4 man crew, 10 hrs/day)	$1,800	days	$54,000
Assume	30	Total days of contractor per diem (4 man crew)	$130	man/day	$3,900
Assume	13	truck loads of waste	$385	per load	$5,005
Assume	20	tons of hazardous IDW	$132	per ton	$2,640
Assume	180	tons of non-hazardous IDW	$38	per ton	$6,840
Assume	131	Wells plugged and abandoned (est. depth 20 ft)	$560	each	$73,360
2. AMEC Oversight					$23,308
Assume	20	per diem/lodging/truck/fuel	$260	per day	$5,109
Assume	197	hours Senior Technician at	$86	per hour	$16,899
Assume	2	airfare	$650	per trip	$1,300
3. Confirmation Sampling and Reporting					$53,158
Assume	41	samples (24 samples per acre)			
Assume	41	Confirmation sample	$640	per sample	$26,240
Assume	6	days of Geoprobe	$2,500	per day	$15,000
Assume	10	hours per technician/day for	6	days per event	
Assume	6	hours sample shipping at	1	per event	
Assume	12	hours mob for technician at	1	per event	
Assume	78	hours for technician at	$86	per hour	$6,708
Assume	6	per diem/lodging/truck/fuel	$260	per event	$1,560
Assume	1	airfare	$650	per trip	$650
Assume	6	days rental equipment at	$500	per day	$3,000
4. Project Management & Reporting					$78,371
Assume	1	Annual Report	$50,000	per report	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$28,371
5. Contingency					$62,416
Assume	1	Contingency	20%		$62,416

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
The expected duration of the above effort is one months.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P2: MONITORED NATURAL ATTENUATION (Annual Cost)				Total:	$159,509
1. Groundwater Monitoring Well Sample Analysis					$61,060
Assume	43	samples (35 well samples, 4 field blanks & 4 duplicates)			
Assume	43	analyzed for VOCs/SVOCs/Pest/Herb/MNA at	$710	per sample	$30,530
Assume	2	sampling events per year at	$30,530	per event	$61,060
2. Labor (for sampling)					$39,780
Assume	12	hours per technician/day for	10	days per event	
Assume	2	hours sample shipping at	1	per event	
Assume	24	hours mob for 2 technicians at	1	per event	
Assume	226	hours for 2 technicians at	$65	per hour	$14,690
Assume	20	days Per Diem/Lodging/Vehicle at	$260	per day	$5,200
Assume	2	sampling events per year at	$19,890	per event	$39,780
3. Rental of Equipment					$10,000
Assume	10	days rental equipment at	$500	per day	$5,000
Assume	2	sampling events per year at	$5,000	per event	$10,000
4. Project Management & Reporting					$22,084
Assume	1	Report	$10,000	Lump Sum	$10,000
Assume	1	AMEC Project management at 10% of all other costs			$12,084
5. Contingency					$26,585
Assume	1	Contingency	20%		$26,585

Note: Field blanks analyzed for VOCs only

Assumes all wells will be sampled for VOCs, SVOCs, pesticides and herbicides.

AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule

Analytical Pricing from TestAmerica Laboratory, Austin Texas.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P2: MONITORED NATURAL ATTENUATION (Well Decommissioning Cost) **Total: $168,064**

1. Monitoring Well Plugging					$88,135
Assume	1	Mob/Demob	$600	ea	$600
Assume	17	Total days of per diem (3 man crew)	$120	man/day	$2,040
Assume	9	CMT Wells Plugged and abandoned at 19/ft Assume wells are 145ft deep each	$2,755	each	$24,795
Assume	9	CMT Wells Backfilled and abandon at 9/ft/145ft	$1,305	each	$11,745
Assume	17	Overdrill 2-inch conventional well depth 35 feet 19/ft	$665	each	$11,305
Assume	17	Overdrill 2-inch conventional well depth 110 feet 19/ft	$1,050	each	$17,850
Assume	33	Backfill and abandon at 9/ft/35ft	$315	each	$10,395
Assume	9	Staging materials	$250	hours	$2,250
Assume	41	State well reports	$10	each	$410
Assume	3	truck loads of waste	$385	per load	$1,155
Assume	3	tons of hazardous IDW	$38	per ton	$114
Assume	30	tons of non-hazardous IDW	$132	per ton	$3,960
Assume	2	waste profiling	$758	per sample	$1,516
2. AMEC Oversight					$29,186
Assume	11	days Per Diem/Lodging/Vehicle at	$260	per day	$2,860
Assume	291	hours Senior Technician at	$86	per hour	$25,026
Assume	2	airfare/parking	$650	per trip	$1,300
3. Project Management & Reporting					$22,732
Assume	1	Report	$10,000	Lump Sum	$10,000
Assume	1	AMEC Project management at 10% of all other costs			$12,732
4. Contingency					$28,011
Assume	1	Contingency	20%		$28,011

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
The expected duration of the above effort is one month.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P3: IN SITU CHEMICAL OXIDATION (Capital Costs)					Total:	$3,673,685
1. Power to Site						$15,000
Assume	$15,000	to drop electrical connection to system, including: • Installation by a qualified electrician; • Installation of main disconnect; • Installation of an electrical meter face.				
2. Process Equipment						$45,000
Assume	1	Prewired, skid mounted 100 gpm chemical oxidation injection system, including: 20 gpm high pressure injection pump 2x 10,000 gallon mixing vessel 2 x 1/2 hp mixers Control system				$45,000
3. System Installation						$2,066,856
Assume	309	Nested stainless steel injection wells	$5,205	per well		$1,608,475
Assume	27	truck loads of IDW	$385	per load		$10,395
Assume	35	tons of hazardous Soil IDW	$132	per ton		$4,560
Assume	311	tons of non-hazardous Soil IDW	$38	per ton		$11,814
Assume	169	IDW profile samples	$758	per sample		$128,102
Assume	7,872	feet of piping at	$30	per linear foot		$236,160
Assume	309	wellhead fittings at	$150	per well		$46,350
Assume	1,600	sqft concrete pad at	$11	per sqft		$17,600
Assume fencing cost to enclose system of			$3,400			$3,400
4. Installation Direction and Oversight						$610,784
Assume	3,090	Project Scientist I	$113	per hour		$349,170
Assume	1,000	Senior Technician	$86	per hour		$86,000
Assume	328	hours of travel to/from the site				$34,899
Assume	409	per diem/lodging/truck/fuel	$260	per day		$106,340
Assume	41	airfare and parking costs of	$650	round trip		$26,650
Assume	31	field supplies cost of	$250	per week		$7,725
5. Project Management & Reporting						$323,764
Assume	1	Installation report & construction drawings	$50,000	Lump Sum		$50,000
Assume	1	AMEC Project management at 10% of all other costs				$273,764
6. Contingency						$612,281
Assume	1	Contingency	20%			$612,281

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
The expected duration of the above effort is nine months.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P3: IN SITU CHEMICAL OXIDATION (Annual Costs)					Total:	$3,277,173
1. Utilities/Oxidizers						$2,217,986
Assume	25	Total water treatment system horsepower				
Assume	8760	System run-time (hours/year)				
Assume	$0.10	per kilowatt hour			Electrical Total:	$16,331
Assume	7471	gallons of 30% hydrogen peroxide solution	$4.59	per gallon		$34,312
Assume	1,441,099	pounds of sodium persulfate	$1.50	per pound		$2,161,648
Assume	2,876,444	gallons of water for sodium persulfate solution	$1.98	per 1,000 gallons		$5,695
2. System Operation						$214,170
Assume	1	technician at	$86	per hour		
Assume	6	hours of travel to/from the site from Houston, TX				$516
Assume	122	hours of system inspection, sampling, and maintenance				$10,492
Assume	30.5	per diem/lodging/truck/fuel	$260	per day		$7,930
Assume	2	airfare and parking costs of	$650	2 round trips/month		$1,300
Assume field supplies cost of			$763	per month		$763
Assume	6	events at	$21,001	per event		$126,003
Assume	1	10 % of wells to be replaced annually @ 50% cost	$88,167	per year		$88,167
3. Fluid Disposal						$30,550
Assume	10000	gallons of hazardous water disposal	$2.50	per gallon		$25,000
Assume	40	hours of vacuum truck (includes transport)	$95	per hour		$3,800
Assume	5	Truck washout	$350	each		$1,750
4. Project Management & Reporting						$268,271
Assume	1	Annual Report	$20,000.00	per report		$20,000
Assume	1	AMEC Project management at 10% of all other costs				$248,271
5. Contingency						$546,195
Assume	1	Contingency	20%			$546,195

Note: Hydrogen peroxide and sodium persulfate pricing from GES
Analytical costs from ALS Laboratories.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P3: IN SITU CHEMICAL OXIDATION (Decommissioning Costs) **Total: $1,559,330**

1. System Decommissioning					$1,076,070
Assume	1	Mob/Demob	$2,500	each	$2,500
Assume	20	Equipment Rental	$350	days	$7,000
Assume	20	Labor (4 man crew, 10 hrs/day)	$1,800	days	$36,000
Assume	80	Total days of per diem (4 man crew)	$480	man/day	$38,400
Assume	36	truck loads of waste	$385	per load	$14,016
Assume	52	tons of hazardous IDW	$132	per ton	$6,815
Assume	516	tons of non-hazardous IDW	$38	per ton	$19,619
Assume	309	Wells plugged and abandoned	$3,080	each	$951,720
2. AMEC Oversight					$55,240
Assume	47	per diem/lodging/truck/fuel	$260	per day	$12,220
Assume	470	hours Senior Technician at	$86	per hour	$40,420
Assume	4	airfare and parking	$650	per trip	$2,600
3. Project Management & Reporting					$168,131
Assume	1	Completion Report	$50,000	Lump Sum	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$118,131
5. Contingency					$259,888
Assume	1	Contingency	20%		$259,888

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
The expected duration of the above effort is two months.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P4: IN SITU ENHANCED BIODEGRADATION (Capital Costs) Total: $3,214,656

1.Process Equipment							$281,000
Assume	1405	Carbon Source Canisters (5 per well)	$200	per canister			$281,000
Assume	1405	Initial Carbon Source (5 Sox per well)	160	per Sox			$224,800
Assume	36	Labor for deployment (days)	1250	days			$45,000
2. System Installation							$1,487,326
Assume	281	Injection wells	$5,205	per well			$1,462,723
Assume	25	truck loads of IDW	$385	per load			$9,625
Assume	32	tons of hazardous Soil IDW	$132	per ton			$4,224
Assume	283	tons of non-hazardous Soil IDW	$38	per ton			$10,754
3. Installation Direction and Oversight							$580,235
Assume	2,810	Project Scientist I	$113	per hour			$317,530
Assume	1,000	Senior Technician	$86	per hour			$86,000
Assume	312	hours of travel to/from the site					$33,045
Assume	381	per diem/lodging/truck/fuel	$260	per day			$99,060
Assume	39	airfare and parking costs of	$650	round trip			$25,350
Assume	77	field supplies cost of	$250	per week			$19,250
4. Baseline Groundwater Sampling							$41,330
Assume	43	samples (35 well samples, 4 field blanks & 4 duplicates)					
Assume	43	samples to be analyzed	$640	per sample	1	event	$27,520
Assume	20	hours sampling per day for	5	days per event			
Assume	2	hours sample shipping/day for	5	days per event			
Assume	24	hours mob for 2 technicians at	1	per event			
Assume	134	hours for 2 technicians at	$65	per hour	1	event	$8,710
Assume	10	per diem/lodging/truck/fuel	$260	lump sum ɼ	1	event	$2,600
Assume	5	days rental equipment at	$500	per day pei	1	event	$2,500
6. Project Management & Reporting							$288,989
Assume	1	Installation report & construction drawings	$50,000	Lump Sum			$50,000
Assume	1	AMEC Project management at 10% of all other costs					$238,989
7. Contingency							$535,776
Assume	1	Contingency	20%				$535,776

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
Groundwater Analytical to establish baseline site conditions prior to system start-up.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P4: IN SITU ENHANCED BIODEGRADATION (Annual Costs)				Total:	$1,777,030
1. Replacement of Carbon Sox/Operation					**$1,341,386**
Assume	5620	Carbon Source Recharge (5 per well - 4 recharges per year)	$160	per carbon Sox	$899,200
Assume	15% markup/shipping				$134,880
Assume	144		$1,250		$180,000
Assume	1	technician at	$86	per hour	
Assume	6	hours of travel to/from the site from Houston, TX			$516
Assume	144	Labor for deployment (days)			$12,384
Assume	144	per diem/lodging/truck/fuel	$260	per day	$37,440
Assume	4	airfare and parking costs of	$650	4 round trips/year	$2,600
Assume	1	10 % of wells to be replaced annually @ 50% cost	$74,366	per year	$74,366
2. Project Management & Reporting					**$156,139**
Assume	1	Annual Report	$20,000	per report	$20,000
Assume	1	AMEC Project management at 10% of all other costs			$136,139
3. Contingency					**$299,505**
Assume	1	Contingency	20%		$299,505

Note:

Analytical costs from ALS Laboratories.
Quarterly monitoring to demonstrate response action effectiveness.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P4: IN SITU ENHANCED BIODEGRADATION (Decommissioning Costs) **Total: $1,651,333**

1. System Decommissioning							$949,380
Assume	1	Mob/Demob	$2,500	each			$2,500
Assume	20	Equipment Rental	$350	days			$7,000
Assume	20	Labor (4 man crew, 10 hrs/day)	$1,800	days			$36,000
Assume	80	Total days of per diem (4 man crew)	$480	man/day			$38,400
Assume	281	Wells plugged and abandoned	$3,080	each			$865,480
2. AMEC Oversight							$86,310
Assume	73	per diem/lodging/truck/fuel	$260	per day			$18,980
Assume	730	hours Senior Technician at	$86	per hour			$62,780
Assume	7	airfare and parking	$650	per trip			$4,550
3. Confirmation Sampling							$165,320
Assume	43	samples (35 well samples, 4 field blanks & 4 duplicates)					
Assume	43	samples to be analyzed	$640	per sample per eve	4	event	$110,080
Assume	20	hours sampling per day for	5	days per event			
Assume	2	hours sample shipping/day for	5	per day			
Assume	24	hours mob for 2 technicians at	1	per event			
Assume	134	hours for 2 technicians at	$65	per hour	4	event	$34,840
Assume	10	per diem/lodging/truck/fuel	$260	lump sum per ever	4	event	$10,400
Assume	5	days rental equipment at	$500	per day per event	4	event	$10,000
4. Project Management & Reporting							$175,101
Assume	1	Completion Report	$50,000	Lump Sum			$50,000
Assume	1	AMEC Project management at 10% of all other costs					$125,101
5. Contingency							$275,222
Assume	1	Contingency	20%				$275,222

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
Assumes one year of quarterly monitoring will be required following system shutdown

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P5: HYDRAULIC CONTROL (Capital Costs)				Total:	$1,633,432
1. Power to Site					$20,000
Assume	$20,000	to drop electrical connection to system, including: • Installation by a qualified electrician; • Installation of main disconnect; • Installation of an electrical meter face.			
2. Process Equipment					$161,000
Assume	1	Prewired, skid mounted 30 gpm water treatment system, including: Oil/water separator Air compressor for pneumatic pumps Tray Aerator 2 X1000 lb carbon vessels 500 gallon storage tank w/ transfer pump			$153,000
Assume	2	Controllerless pneumatic pumps	$4,000	per pump	$8,000
3. System Installation					$978,751
Assume	977	feet of interceptor trench	$350	per foot	$341,950
Assume	2	trench sumps	$25,000	per sump	$50,000
Assume	145	cubic yards of filter pack	$9.58	per cubic yard	$1,387
Assume	24	Loader	$86.63	per hour	$2,079
Assume	12	truck loads of IDW	$385	per load	$4,644
Assume	21	tons of hazardous IDW	$132	per ton	$2,746
Assume	187	tons of non-hazardous IDW	$38	per ton	$7,115
Assume	563	IDW profile samples	$758	per sample	$426,754
Assume	513	feet of trenching at	$30	per linear foot	$15,390
Assume	513	feet of piping at	$30	per linear foot	$15,390
Assume	513	feet of resurfacing at	$12	per linear foot	$6,156
Assume	2	wellhead fittings at	$400	per well	$800
Assume	900	sqft concrete pad at	$11	per sqft	$9,900
Assume fencing cost to enclose system of			$3,400		$3,400
Assume	12	Water analytical at startup	$920	per sample	$11,040
Assume	1	NPDES Permit/Air Emissions Permit	$80,000	lump sum	$80,000
4. Installation Direction and Oversight					$27,698
Assume	200	Senior Technician	$86	per hour	$17,226
Assume	24	hours of travel to/from the site			$2,064
Assume	20	per diem/lodging/truck/fuel	$260	per day	$5,208
Assume	3	airfare and parking costs of	$650	round trip.	$1,950
Assume	5	field supplies cost of	$250	per week	$1,250
5. Project Management & Reporting					$173,745
Assume	1	Installation report & construction drawings	$50,000	Lump Sum	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$123,745
6. Contingency					$272,239
Assume	1	Contingency	20%		$272,239

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
The expected duration of the above effort is one month.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P5: HYDRAULIC CONTROL (Annual Costs)					Total:	$166,150
1. Utilities/Carbon						$23,799
Assume	15	Total water treatment system horsepower				
Assume	8760	System run-time (hours/year)				
Assume	$0.10	per kilowatt hour			Electrical Total:	$9,799
Assume	4	Carbon Changes at	$3,500		per change:	$14,000
2. NPDES/Air EmissionsAnalytical Costs						$21,720
Assume	12	VOC in water analysis	$125	per sample		$1,500
Assume	12	SVOC in water analysis	$250	per sample		$3,000
Assume	12	RCRA metals in water analysis	$100	per sample		$1,200
Assume	12	TPH in water analysis	$60	per sample		$720
Assume	12	Pesticides in water analysis	$350	per sample		$4,200
Assume	12	Metals in water analysis	$100	per sample		$1,200
Assume	36	TO-14 analysis	$275	per sample		$9,900
3. System Operation						$63,816
Assume	1	technician at	$86	per hour		
Assume	6	hours of travel to/from the site from Houston, TX				$516
Assume	32	hours of system inspection, sampling, and maintenance				$2,752
Assume	5	per diem/lodging/truck/fuel	$260	per day		$1,300
Assume airfare and parking costs of			$650	round trip.		$650
Assume field supplies cost of			$100	per inspection		$100
Assume	12	events at	$5,318	per event		$63,816
4. Fluid Disposal						$1,550
Assume	100	gallons of hazardous liquid disposal	$2.50	per gallon		$250
Assume	10	hours of vacuum truck (includes transport)	$95	per hour		$950
Assume	1	Truck washout	$350	each		$350
6. Project Management & Reporting						$33,088
Assume	1	Annual Report	$20,000	per report		$20,000
Assume	1	AMEC Project management at 10% of all other costs				$13,088
7. Contingency						$22,177
Assume	1	Contingency	20%			$22,177

Note: Carbon pricing from Siemens (formerly US Filter)
Analytical costs from ALS Laboratories.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P5: HYDRAULIC CONTROL (Decommissioning Costs)							Total:	$366,799
1. System Decommissioning								$36,148
Assume	1	Mob/Demob	$2,500	each				$2,500
Assume	10	Equipment Rental	$350	days				$3,500
Assume	10	Labor (4 man crew, 10 hrs/day)	$1,800	days				$18,000
Assume	20	Total days of per diem (4 man crew)	$120	man/day				$2,400
Assume	4	truck loads of waste	$385	per load				$1,540
Assume	4	tons of hazardous IDW	$132	per ton				$528
Assume	40	tons of non-hazardous IDW	$38	per ton				$1,520
Assume	2	Sumps plugged and abandoned	$3,080	each				$6,160
2. AMEC Oversight								$26,410
Assume	23	per diem/lodging/truck/fuel	$260	per day				$5,980
Assume	230	hours Senior Technician at	$86	per hour				$19,780
Assume	1	airfare	$650	per trip				$650
3. Confirmation Sampling								$165,320
Assume	43	samples (35 well samples, 4 field blanks & 4 duplicates)						
Assume	43	samples to be analyzed	$640	per sample per event	4	event		$110,080
Assume	20	hours sampling per day for	5	days per event				
Assume	2	hours sample shipping/day for	5	per day				
Assume	24	hours mob for 2 technicians at	1	per event				
Assume	134	hours for 2 technicians at	$65	per hour	4	event		$34,840
Assume	10	per diem/lodging/truck/fuel	$260	per day	4	event		$10,400
Assume	5	days rental equipment at	$500	per day per event	4	event		$10,000
4. Project Management & Reporting								$77,788
Assume	1	Completion Report	$50,000	Lump Sum				$50,000
Assume	1	AMEC Project management at 10% of all other costs						$27,788
5. Contingency								$61,133
Assume	1	Contingency	20%					$61,133

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
The expected duration of the above effort is one month.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P6: PERMEABLE REACTIVE BARRIERS (Capital Costs)							Total:	$1,167,568
1. System Installation								$810,061
Assume	560	feet of PRB trench	$400	per foot				$224,000
Assume	3,000	cubic yards of filler media (mulch)	$50	per cubic yard				$150,000
Assume	15	Support Equipment	$1,000	per day				$15,000
Assume	1	Site Preparation	$30,000	each				$30,000
Assume	250	truck loads of IDW	$385	per load				$96,250
Assume	300	tons of hazardous IDW	$132	per ton				$39,600
Assume	2,700	tons of non-hazardous IDW	$38	per ton				$102,600
Assume	167	IDW profile samples	$758	per sample				$126,586
Assume	5	Monitoring Wells	$5,205	per well				$26,025
2. Installation Direction and Oversight								$15,970
Assume	112	Senior Technician	$86	per hour				$9,632
Assume	16	hours of travel to/from the site						$1,376
Assume	11	per diem/lodging/truck/fuel	$260	per day				$2,912
Assume	2	airfare and parking costs of	$650	round trip.				$1,300
Assume	3	field supplies cost of	$250	per week				$750
3. Baseline Groundwater Sampling								$8,490
Assume	7	samples (well samples, field blanks & duplicates)						
Assume	7	samples to be analyzed	$640	per samp	1	event		$4,480
Assume	20	hours sampling per day for	1	days per event				
Assume	2	hours sample shipping/day for	1	per day				
Assume	24	hours mob for 2 technicians at	1	per event				
Assume	46	hours for 2 technicians at	$65	per hour	1	event		$2,990
Assume	2	per diem/lodging/truck/fuel	$260	per event	1	event		$520
Assume	1	days rental equipment at	$500	per day p	1	event		$500
4. Project Management & Reporting								$138,452
Assume	1	Installation report & construction drawings	$50,000	Lump Sum				$50,000
Assume	1	AMEC Project management at 10% of all other costs						$88,452
5. Contingency								$194,595
Assume	1	Contingency	20%					$194,595

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
Groundwater analytical to establish baseline site conditions prior to system start-up.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P6: PERMEABLE REACTIVE BARRIERS (Annual Costs)						Total:	$73,952
1.Quarterly Groundwater Sampling							$36,024
Assume	7	samples (well samples, field blanks & duplicates)					
Assume	7	samples to be analyzed	$640	per sample per even	4	event	$17,920
Assume	20	hours sampling per day for	1	days per event			
Assume	2	hours sample shipping/day for	1	per day			
Assume	24	hours mob for 2 technicians at	1	per event			
Assume	46	hours for 2 technicians at	$65	per hour	4	event	$11,960
Assume	1	technician at	$86	per hour			
Assume	6	hours of travel to/from the site from Houston, TX			4	event	$2,064
Assume	2	per diem/lodging/truck/fuel	$260	lump sum per event	4	event	$2,080
Assume	1	days rental equipment at	$500	per day per event	4	event	$2,000
2. Project Management & Reporting							$25,602
Assume	1	Annual Report	$20,000.00	per report			$20,000
Assume	1	AMEC Project management at 10% of all other costs					$5,602
3. Contingency							$12,325
Assume	1	Contingency	20%				$12,325

Note:

Analytical costs from ALS Laboratories.
Quarterly monitoring to demonstrate response action effectiveness.

PERCHED ZONE GROUNDWATER REMEDY ALTERNATIVE P6: PERMEABLE REACTIVE BARRIERS (Decommissioning Costs) **Total: $209,297**

1. System Decommissioning								$51,548
Assume	1	Mob/Demob	$2,500	each				$2,500
Assume	10	Equipment Rental	$350	days				$3,500
Assume	10	Labor (4 man crew, 10 hrs/day)	$1,800	days				$18,000
Assume	20	Total days of per diem (4 man crew)	$120	man/day				$2,400
Assume	4	truck loads of waste	$385	per load				$1,540
Assume	4	tons of hazardous IDW	$132	per ton				$528
Assume	40	tons of non-hazardous IDW	$38	per ton				$1,520
Assume	7	Wells plugged and abandoned	$3,080	each				$21,560
2. AMEC Oversight								$23,050
Assume	20	per diem/lodging/truck/fuel	$260	per day				$5,200
Assume	200	hours Senior Technician at	$86	per hour				$17,200
Assume	1	airfare	$650	per trip				$650
3. Confirmation Sampling								$33,960
Assume	7	samples (well samples, field blanks & duplicates)						
Assume	7	samples to be analyzed	$640	per sample	4	event		$17,920
Assume	20	hours sampling per day for	1	days per event				
Assume	2	hours sample shipping/day for	1	per day				
Assume	24	hours mob for 2 technicians at	1	per event				
Assume	46	hours for 2 technicians at	$65	per hour	4	event		$11,960
Assume	2	per diem/lodging/truck/fuel	$260	per day	4	event		$2,080
Assume	1	days rental equipment at	$500	per day per	4	event		$2,000
4. Project Management & Reporting								$65,856
Assume	1	Completion Report	$50,000	Lump Sum				$50,000
Assume	1	AMEC Project management at 10% of all other costs						$15,856
5. Contingency								$34,883
Assume	1	Contingency	20%					$34,883

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
Assumes one year of quarterly monitoring will be required following system shutdown
PRB left in place.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A2: MONITORED NATURAL ATTENUATION (Capital Costs)					Total:	$165,286
1. Off-Site Monitoring Well Installation						$98,003
Assume	6	Monitoring wells (including surface completions)	$14,500	per well (12,000 for well and 2,500 for development)		$87,000
Assume	2	truck loads of IDW	$385	per load		$770
Assume	2	tons of hazardous IDW	$132	per ton		$317
Assume	22	tons of non-hazardous IDW	$38	per ton		$820
Assume	12	IDW profile samples	$758	per sample		$9,096
2. Installation Direction and Oversight						$24,214
Assume	180	Project Scientist I	$113	per hour		$20,340
Assume	8	hours of travel to/from the site				$904
Assume	7	per diem/lodging/truck/fuel	$260	per day		$1,820
Assume	1	airfare and parking costs of	$650	round trip		$650
Assume	2	field supplies cost of	$250	per week		$500
3. Project Management & Reporting						$15,522
Assume	1	Boring logs & construction drawings	$3,000	Lump Sum		$3,000
Assume	1	AMEC Project management at 10% of all other costs				$12,522
4. Contingency						$27,548
Assume	1	Contingency	20%			$27,548

Note: Pricing from TECHSAS and Boart-Longyear

AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.

The expected duration of the above effort is two weeks.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A2: MONITORED NATURAL ATTENUATION (Annual Cost)				Total:	$161,383
1. Groundwater Monitoring Well Sample Analysis					$62,480
Assume	44	samples (36 well samples, 4 field blanks & 4 duplicates)			
Assume	44	analyzed for VOCs/SVOCs/Pest/Herb/MNA at	$710	per sample	$31,240
Assume	2	sampling events per year at	$31,240	per event	$62,480
2. Labor (for sampling)					$39,780
Assume	12	hours per technician/day for	10	days per event	
Assume	2	hours sample shipping at	1	per event	
Assume	24	hours mob for 2 technicians at	1	per event	
Assume	226	hours for 2 technicians at	$65	per hour	$14,690
Assume	20	days Per Diem/Lodging/Vehicle at	$260	per day	$5,200
Assume	2	sampling events per year at	$19,890	per event	$39,780
3. Rental of Equipment					$10,000
Assume	10	days rental equipment at	$500	per day	$5,000
Assume	2	sampling events per year at	$5,000	per event	$10,000
4. Project Management & Reporting					$22,226
Assume	1	Report	$10,000	Lump Sum	$10,000
Assume	1	AMEC Project management at 10% of all other costs			$12,226
5. Contingency					$26,897
Assume	1	Contingency	20%		$26,897

Note: Field blanks analyzed for VOCs only
Assumes all wells will be sampled for VOCs, SVOCs, pesticides and herbicides.
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
Analytical Pricing from TestAmerica Laboratory, Austin Texas.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A2: MONITORED NATURAL ATTENUATION (Well Decommissioning Cost) — **Total: $144,713**

1. Monitoring Well Plugging					$83,269
Assume	1	Mob/Demob	$600	ea	$600
Assume	14	Total days of per diem (3 man crew)	$120	man/day	$1,680
Assume	10	CMT Wells Plugged and abandoned at 19/ft Assume wells are 145ft deep each	$2,755	each	$27,550
Assume	10	CMT Wells Backfilled and abandon at 9/ft/145ft	$1,305	each	$13,050
Assume	14	Overdrill 2-inch conventional well depth 35 feet 19/ft	$665	each	$9,310
Assume	14	Overdrill 2-inch conventional well depth 110 feet 19/ft	$1,050	each	$14,700
Assume	28	Backfill and abandon at 9/ft/35ft	$315	each	$8,820
Assume	7	Staging materials	$250	hours	$1,750
Assume	35	State well reports	$10	each	$350
Assume	3	truck loads of waste	$385	per load	$1,155
Assume	3	tons of hazardous IDW	$38	per ton	$114
Assume	26	tons of non-hazardous IDW	$132	per ton	$3,432
Assume	1	waste profiling	$758	per sample	$758
2. AMEC Oversight					$16,362
Assume	6	days Per Diem/Lodging/Vehicle at	$260	per day	$1,560
Assume	157	hours Senior Technician at	$86	per hour	$13,502
Assume	2	airfare/parking	$650	per trip	$1,300
3. Project Management & Reporting					$20,963
Assume	1	Report	$10,000	Lump Sum	$10,000
Assume	1	AMEC Project management at 10% of all other costs			$10,963
4. Contingency					$24,119
Assume	1	Contingency	20%		$24,119

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
The expected duration of the above effort is one month.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A3: IN SITU ENHANCED BIODEGRADATION
(Capital Cost) **Total: $1,183,260**

1.Process Equipment							$89,000
Assume	445	Carbon Canisters (5 per well)	$200	per canister			$89,000
Assume	445	Initial Carbon Charge (5 Sox per well)	160	per Sox			$71,200
Assume	12	Labor for deployment (days)	1250	days			$15,000
2. System Installation							$480,260
Assume	89	Wells (83 injection + 6 monitoring)	$5,205	per well			$463,245
Assume	23	truck loads of IDW	$385	per load			$8,855
Assume	10	tons of hazardous Soil IDW	$132	per ton			$1,320
Assume	180	tons of non-hazardous Soil IDW	$38	per ton			$6,840
3. Installation Direction and Oversight							$272,565
Assume	890	Project Scientist I	$113	per hour			$100,570
Assume	1,000	Senior Technician	$86	per hour			$86,000
Assume	152	hours of travel to/from the site					$15,005
Assume	189	per diem/lodging/truck/fuel	$260	per day			$49,140
Assume	19	airfare and parking costs of	$650	round trip			$12,350
Assume	38	field supplies cost of	$250	per week			$9,500
4. Baseline Groundwater Sampling							$9,130
Assume	8	samples 8 (well samples, field blanks & duplicates)					
Assume	8	samples to be analyzed	$640	per sample	1	event	$5,120
Assume	20	hours sampling per day for	1	days per event			
Assume	2	hours sample shipping/day for	1	days per event			
Assume	24	hours mob for 2 technicians at	1	per event			
Assume	46	hours for 2 technicians at	$65	per hour	1	event	$2,990
Assume	2	per diem/lodging/truck/fuel	$260	lump sum p	1	event	$520
Assume	1	days rental equipment at	$500	per day per	1	event	$500
6. Project Management & Reporting							$135,095
Assume	1	Installation report & construction drawings	$50,000	Lump Sum			$50,000
Assume	1	AMEC Project management at 10% of all other costs					$85,095
7. Contingency							$197,210
Assume	1	Contingency	20%				$197,210

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
Groundwater Analytical to establish baseline site conditions prior to system start-up.
The expected duration for the above effort is six months.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A3: IN SITU ENHANCED BIODEGRADATION (Annual Costs) Total: $908,850

1. Replacement of Carbon Sox/Operation					$683,674
Assume	2670	Carbon Recharge (5 per well - 6 recharges per year)	$160	per carbon Sox	$427,200
Assume	15% markup/shipping				$64,080
Assume	72		$1,250		$90,000
Assume	1	technician at	$86	per hour	
Assume	6	hours of travel to/from the site from Houston, TX			$516
Assume	72	Labor for deployment (days)			$6,192
Assume	72	per diem/lodging/truck/fuel	$260	per day	$18,720
Assume	4	airfare and parking costs of	$650	4 round trips/year	$2,600
Assume	1	10 % of wells to be replaced annually @ 50% cost	$74,366	per year	$74,366
2. Project Management & Reporting					$90,367
Assume	1	Annual Report	$20,000.00	per report	$20,000
Assume	1	AMEC Project management at 10% of all other costs			$70,367
3. Contingency					$154,808
Assume	1	Contingency	20%		$154,808

Note:

Analytical costs from ALS Laboratories.
Quarterly monitoring to demonstrate response action effectiveness.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A3: IN SITU ENHANCED BIODEGRADATION **Total: $946,519**
(Decommissioning Costs)

1. System Decommissioning							$292,900
Assume	1	Mob/Demob	$2,500	each			$2,500
Assume	4	Equipment Rental	$350	days			$1,400
Assume	4	Labor (4 man crew, 10 hrs/day)	$1,800	days			$7,200
Assume	16	Total days of per diem (4 man crew)	$480	man/day			$7,680
Assume	89	Wells plugged and abandoned	$3,080	each			$274,120
2. AMEC Oversight							$51,880
Assume	44	per diem/lodging/truck/fuel	$260	per day			$11,440
Assume	440	hours Senior Technician at	$86	per hour			$37,840
Assume	4	airfare and parking	$650	per trip			$2,600
3. Confirmation Sampling							$322,280
Assume	89	samples (35 well samples, 4 field blanks & 4 duplicates)					
Assume	89	samples to be analyzed	$640	per sample	4	event	$227,840
Assume	20	hours sampling per day for	9	days per event			
Assume	2	hours sample shipping/day for	9	per day			
Assume	24	hours mob for 2 technicians at	1	per event			
Assume	222	hours for 2 technicians at	$65	per hour	4	event	$57,720
Assume	18	per diem/lodging/truck/fuel	$260	lump sum p	4	event	$18,720
Assume	9	days rental equipment at	$500	per day per	4	event	$18,000
4. Project Management & Reporting							$121,706
Assume	1	Completion Report	$50,000	Lump Sum			$50,000
Assume	1	AMEC Project management at 10% of all other costs					$71,706
5. Contingency							$157,753
Assume	1	Contingency	20%				$157,753

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
Assumes one year of quarterly monitoring will be required following system shutdown

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A4: HYDRAULIC CONTROL (Capital Costs)				Total:	$8,048,186
1. Power to Site					$50,000
Assume	$50,000	to drop electrical connection to system, including: • Installation by a qualified electrician; • Installation of main disconnect; • Installation of an electrical meter face.			
2. Process Equipment					$2,210,000
Assume	1	Prewired, skid mounted 1,000 gpm water treatment system, including: Oil/water separator Air compressor for pneumatic pumps Tray Aerator 2 X 5000 lb carbon vessels 2,000 gallon storage tank w/ transfer pump Lift Station Pumps and Controls			$1,902,000
Assume	77	Controllerless pneumatic pumps	$4,000	per pump	$308,000
3. System Installation					$3,312,720
Assume	77	70' wells	$5,948	per well	$457,997
Assume	77	110' wells	$9,347	per well	$719,710
Assume	77	150'wells	$12,746	per well	$981,423
Assume	36	truck loads of IDW	$385	per load	$13,860
Assume	47	tons of hazardous IDW	$132	per ton	$6,233
Assume	425	tons of non-hazardous IDW	$38	per ton	$16,149
Assume	231	IDW profile samples	$758	per sample	$175,098
Assume	7,853	feet of trenching at	$30	per linear foot	$235,590
Assume	7,853	feet of piping at	$45	per linear foot	$353,385
Assume	7,853	feet of resurfacing at	$12	per linear foot	$94,236
Assume	77	wellhead fittings at	$1,000	per well	$77,000
Assume	1,600	sqft concrete pad at	$11	per sqft	$17,600
Assume fencing cost to enclose system of			$3,400		$3,400
Assume	1	Lift station install and sewer tie-in	$70,000	lump sum	$70,000
Assume	12	Water analytical at startup	$920	per sample	$11,040
Assume	1	NPDES Permit/Air Emissions Permit	$80,000	lump sum	$80,000
4. Installation Direction and Oversight					$474,390
Assume	2,310	Project Scientist I	$113	per hour	$261,030
Assume	800	Senior Technician	$86	per hour	$68,800
Assume	256	hours of travel to/from the site			$27,150
Assume	311	per diem/lodging/truck/fuel	$260	per day	$80,860
Assume	32	airfare and parking costs of	$650	round trip.	$20,800
Assume	63	field supplies cost of	$250	per week	$15,750
5. Project Management & Reporting					$659,711
Assume	1	Installation report & construction drawings	$50,000	Lump Sum	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$609,711
6. Contingency					$1,341,364
Assume	1	Contingency	20%		$1,341,364

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
The expected duration of the above effort is one year.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A4: HYDRAULIC CONTROL (Annual Costs)						Total:	$810,201
1. Utilities/Carbon							$299,942
Assume	352	Total water treatment system horsepower					
Assume	8760	System run-time (hours/year)					
Assume	$0.10	per kilowatt hour			Electrical Total:		$229,942
Assume	4	Carbon Changes at	$17,500		per change:		$70,000
2. NPDES/Air EmissionsAnalytical Costs							$21,720
Assume	12	VOC in water analysis	$125	per sample			$1,500
Assume	12	SVOC in water analysis	$250	per sample			$3,000
Assume	12	RCRA metals in water analysis	$100	per sample			$1,200
Assume	12	TPH in water analysis	$60	per sample			$720
Assume	12	Pesticides in water analysis	$350	per sample			$4,200
Assume	12	Metals in water analysis	$100	per sample			$1,200
Assume	36	TO-14 analysis	$275	per sample			$9,900
3. System Operation							$172,777
Assume	1	technician at	$86	per hour			
Assume	6	hours of travel to/from the site from Houston, TX					$516
Assume	32	hours of system inspection, sampling, and maintenance					$2,752
Assume	5	per diem/lodging/truck/fuel	$260	per day			$1,300
Assume airfare and parking costs of			$650	round trip.			$650
Assume field supplies cost of			$100	per inspection			$100
Assume	12	events at	$5,318	per event			$63,816
Assume	1	10 % of wells to be replaced annually @ 50% cost	$108,961	lump sum			$108,961
4. Fluid Disposal							$30,550
Assume	10000	gallons of hazardous water disposal	$2.50	per gallon			$25,000
Assume	40	hours of vacuum truck (includes transport)	$95	per hour			$3,800
Assume	5	Truck washout	$350	each			$1,750
5. Semi-Annual Groundwater Sampling							$68,800
Assume	36	samples (30 well samples, 3 field blanks & 3 duplicates)					
Assume	36	samples to be analyzed	$640	per sample per event		2 event	$46,080
Assume	20	hours sampling per day for	4	days per event			
Assume	2	hours sample shipping/day for	4	per day			
Assume	24	hours mob for 2 technicians at	1	per event			
Assume	112	hours for 2 technicians at	$65	per hour		2 event	$14,560
Assume	8	per diem/lodging/truck/fuel	$260	lump sum per event		2 event	$4,160
Assume	4	days rental equipment at	$500	per day per event		2 event	$4,000
6. Project Management & Reporting							$81,379
Assume	1	Annual Report	$20,000	per report			$20,000
Assume	1	AMEC Project management at 10% of all other costs					$61,379
7. Contingency							$135,034
Assume	1	Contingency	20%				$135,034

Note: Carbon pricing from Siemens (formerly US Filter)
Analytical costs from ALS Laboratories.
Semi-annual monitoring to demonstrate response action effectiveness.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A4: HYDRAULIC CONTROL (Decommisioning Costs) **Total: $1,136,388**

1. System Decommissioning					**$742,690**
Assume	1	Mob/Demob	$1,000	each	$1,000
Assume	10	Equipment Rental	$350	days	$3,500
Assume	10	Labor (4 man crew, 10 hrs/day)	$1,800	days	$18,000
Assume	40	Total days of per diem (4 man crew)	$120	man/day	$4,800
Assume	4	truck loads of waste	$385	per load	$1,540
Assume	5	tons of hazardous IDW	$132	per ton	$660
Assume	45	tons of non-hazardous IDW	$38	per ton	$1,710
Assume	231	Wells plugged and abandoned	$3,080	each	$711,480
2. AMEC Oversight					**$68,210**
Assume	58	per diem/lodging/truck/fuel	$260	per day	$15,080
Assume	580	hours Senior Technician at	$86	per hour	$49,880
Assume	5	airfare	$650	per trip	$3,250
3. Project Management & Reporting					**$136,090**
Assume	1	Completion Report	$50,000	Lump Sum	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$86,090
4. Contingency					**$189,398**
Assume	1	Contingency	20%		$189,398

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
The expected duration of the above effort is three months.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A5: IN SITU CHEMICAL OXIDATION (Capital Costs) Total: $8,026,158

1. Power to Site					$15,000
Assume	$15,000	to drop electrical connection to system, including: • Installation by a qualified electrician; • Installation of main disconnect; • Installation of an electrical meter face.			
2. Process Equipment					$45,000
Assume	1	Prewired, skid mounted 100 gpm chemical oxidation injection system, including: 20 gpm high pressure injection pump 2x 10,000 gallon mixing vessel 2 x 1/2 hp mixers Control system			$45,000
3. System Installation					$5,346,864
Assume	309	Nested stainless steel injection wells	$14,655	per well	$4,528,525
Assume	87	truck loads of IDW	$385	per load	$33,495
Assume	115	tons of hazardous IDW	$132	per ton	$15,200
Assume	1,036	tons of non-hazardous IDW	$38	per ton	$39,381
Assume	563	IDW profile samples	$758	per sample	$426,754
Assume	7,872	feet of piping at	$30	per linear foot	$236,160
Assume	309	wellhead fittings at	$150	per well	$46,350
Assume	1,600	sqft concrete pad at	$11	per sqft	$17,600
Assume fencing cost to enclose system of			$3,400		$3,400
4. Installation Direction and Oversight					$623,559
Assume	3,090	Project Scientist I	$113	per hour	$349,170
Assume	1,000	Senior Technician	$86	per hour	$86,000
Assume	328	hours of travel to/from the site			$34,899
Assume	409	per diem/lodging/truck/fuel	$260	per day	$106,340
Assume	41	airfare and parking costs of	$650	round trip	$26,650
Assume	82	field supplies cost of	$250	per week	$20,500
5. Project Management & Reporting					$658,042
Assume	1	Installation report & construction drawings	$50,000	Lump Sum	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$608,042
6. Contingency					$1,337,693
Assume	1	Contingency	20%		$1,337,693

Note: Pricing from TECHSAS and Boart-Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule.
The expected duration of the above effort is one year.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A5: IN SITU CHEMICAL OXIDATION (Annual Costs)					Total:	$3,493,653
1. Utilities/Oxidizers						$2,217,986
Assume	25	Total water treatment system horsepower				
Assume	8760	System run-time (hours/year)				
Assume	$0.10	per kilowatt hour			Electrical Total:	$16,331
Assume	7471	gallons of 30% hydrogen peroxide solution	$4.59	per gallon		$34,312
Assume	1,441,099	pounds of sodium persulfate	$1.50	per pound		$2,161,648
Assume	2,876,444	gallons of water for sodium persulfate solution	$1.98	per 1,000 gallons		$5,695
2. System Operation						$378,171
Assume	1	technician at	$86	per hour		
Assume	6	hours of travel to/from the site from Houston, TX				$516
Assume	122	hours of system inspection, sampling, and maintenance				$10,492
Assume	31	per diem/lodging/truck/fuel	$260	per day		$7,930
Assume	2	airfare and parking	$650	2 round trips/month		$1,300
Assume field supplies cost of			$763	per month		$763
Assume	6	months of operation per injection event	$21,001	per month		$126,003
Assume	1	10 % of wells to be replaced annually @ 50% cost	$252,168	lump sum		$252,168
3. Fluid Disposal						$30,550
Assume	10000	gallons of hazardous liquid disposal	$2.50	per gallon		$25,000
Assume	40	hours of vacuum truck (includes transport)	$95	per hour		$3,800
Assume	5	Truck washout	$350	each		$1,750
6. Project Management & Reporting						$284,671
Assume	1	Annual Report	$20,000.00	per report		$20,000
Assume	1	AMEC Project management at 10% of all other costs				$264,671
7. Contingency						$582,276
Assume	1	Contingency	20%			$582,276

Note: Hydrogen peroxide and sodium persulfate pricing from GES
Analytical costs from ALS Laboratories.
Quarterly monitoring to demonstrate response action effectiveness.

ALLUVIAL AQUIFER GROUNDWATER REMEDY ALTERNATIVE A5: IN SITU CHEMICAL OXIDATION (Decommissioning Costs) Total: $1,559,330

1. System Decommissioning					$1,076,070
Assume	1	Mob/Demob	$2,500	each	$2,500
Assume	20	Equipment Rental	$350	days	$7,000
Assume	20	Labor (4 man crew, 10 hrs/day)	$1,800	days	$36,000
Assume	80	Total days of per diem (4 man crew)	$480	man/day	$38,400
Assume	36	truck loads of waste	$385	per load	$14,016
Assume	52	tons of hazardous IDW	$132	per ton	$6,815
Assume	516	tons of non-hazardous IDW	$38	per ton	$19,619
Assume	309	Wells plugged and abandoned	$3,080	each	$951,720
2. AMEC Oversight					$55,240
Assume	47	per diem/lodging/truck/fuel	$260	per day	$12,220
Assume	470	hours Senior Technician at	$86	per hour	$40,420
Assume	4	airfare	$650	per trip	$2,600
3. Project Management & Reporting					$168,131
Assume	1	Completion Report	$50,000	per report	$50,000
Assume	1	AMEC Project management at 10% of all other costs			$118,131
4. Contingency					$259,888
Assume	1	Contingency	20%		$259,888

Note: P&A Costs from Best Drilling and Boart Longyear
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Schedule
The expected duration of the above effort is two months.

APPENDIX C

Breakdown of Estimated Costs for Demolition, Drum Vault, and Wastewater Treatment Ponds

DEMOLITION COSTS				Total:	$4,639,180.00
1. Demolition					$4,337,500.00
Assume	67,500	sqft of buildings	$5.00	per sqft	$337,500.00
Assume a flat rate to demo process equipment and piping of					$4,000,000.00
2. Project Oversight					$301,680.00
Assume	9	months Office Trailer at	$500.00	per month	$4,500.00
Assume	270	days Per Diem/Lodging at	$130.00	per day	$35,100.00
Assume	2700	hours Senior Technician at	$86.00	per hour	$232,200.00
Assume	9	airfares (4 wks on, 1 wk off) at	$470.00	per trip	$4,230.00
Assume	270	days vehicle rental at	$65	per day	$17,550
Assume	270	days vehicle fuel at	$30	per day	$8,100

Note: Demolition pricing from Alamo 1
Labor Pricing from Cedar Chemical Pricing Sheet
Demolition Costs do not include slabs or pavement

DRUM VAULT				TOTAL:	$742,995.55
1. Mobilization/Demobilization & Rental Equipment					$153,968.00
Assume	1	Mobilization/Demobilization (crew)	$1,950.00	each	$1,950.00
Assume	2	Track Hoe Delivery/Pickup	$1,200.00	each	$2,400.00
Assume	1	Track Hoe With Thumb Rental (picking up demo material)	$5,520.00	per month	$5,520.00
Assume	1	Track Hoe Rental (Tearing down)	$5,718.00	per week	$5,718.00
Assume	60	Roll Off Box Delivery/Pickup	$720.00	each	$43,200.00
Assume	120	Roll Off Box Rental	$20.00	each	$2,400.00
Assume	120	Roll Off Box Liners	$40.00	each	$4,800.00
Assume	2	Frac Tank Delivery	$720.00	each	$1,440.00
Assume	30	Frac Tank Rental	$75.00	each	$2,250.00
Assume	1	Hydraulic Breaker Rental	$5,720.00	per month	$5,720.00
Assume	1	Roll Off Frame (Onsite to Spot Boxes)	$7,800.00	each	$7,800.00
Assume	1	Third Party Air Monitoring	$45,000.00	each	$45,000.00
Assume	2	Dozer (D-3 or Equivalent) Delivery/Pickup	$1,200.00	each	$2,400.00
Assume	1	Dozer (D-3 or Equivalent)	$1,590.00	per week	$1,590.00
Assume	165	Backfill Delivered	$132.00	per load	$21,780.00
2. Warehouse Demolition - Level D					$19,010.00
Assume	3	Warehouse Demolition	$4,675.00	per day	$14,025.00
Assume	3	Transportation to Local Recycler	$995.00	per day	$2,985.00
Assume	20	Warehouse demo to landfill as Class 2 Waste	$25.00	tons	$2,000.00
3. Concrete Removal - Level B					$23,550.00
Assume	3	Concrete Demo/Loading in Roll Off Boxes	$7,850.00	per day	$23,550.00
4. Vacuum Liquid from Vault - Level B (Confined Space)					$36,725.00
Assume	3	Vacuum Liquid From Vault	$10,250.00	per day	$30,750.00
Assume	1	Frac Tank Cleaning	$5,975.00	per day	$5,975.00
5. Solidify Sludge/Slurry in Vault - Level B (Confined Space)					$47,094.55
Assume	5	Solidify Sludge & Load In Roll Off Boxes	$9,300.00	per day	$46,500.00
Assume	2	Solidification Agent (Bentonite)	$297.27	per ton	$594.55
6. Sludge Removal From Vault in Roll Off Boxes - Level B					$46,500.00
Assume	5	Sludge Removal From Vault	$9,300.00	per day	$46,500.00
7. Back Fill of Vault with Soil					$13,278.00
Assume	3	Backfill Vault	$4,426.00	per day	$13,278.00
8. Disposal					$187,420.00
Assume	3500	Disposal of Solid Waste Non-Hazardous	$25.20	per ton	$88,200.00
Assume	120	Trans of Solid Non-Hazardous Waste	$270.00	per trip	$32,400.00
Assume	110	Disposal of Liquid Waste Non-Hazardous	$102.00	per ton	$11,220.00
Assume	8	Trans of Liquid Non-Hazardous Waste	$1,350.00	per trip	$10,800.00
Assume	128	Certified Truck Washout	$350.00	each	$44,800.00
9. Subcontractor Project Oversight					$22,100.00
Assume	1	Office Trailer	$500.00	per month	$500.00
Assume	150	Per Diem/Lodging each man	$125.00	per day	$18,750.00
Assume	30	days vehicle rental	$65	per day	$1,950
Assume	30	days vehicle fuel	$30	per day	$900
Assume	1500	Technician	$65	per day	$97,500
10. AMEC Project Oversight					$193,350.00
Assume	150	days Per Diem/Lodging at	$130.00	per day	$19,500.00
Assume	1500	hours Senior Technician at	$86.00	per hour	$129,000.00
Assume	150	hours Project Management	$160.00	per hous	$24,000.00
Assume	5	airfares at	$470.00	per trip	$2,350.00
Assume	155	days vehicle rental at	$100	per day	$15,500
Assume	100	days vehicle fuel at	$30	per day	$3,000

Note: Subcontractor cost from USES 2008 Pricing
AMEC Labor and Expenses Pricing from Cedar Chemical 2009 Pricing Schedule

FUTURE POND CLOSURES (Stabilization)				Total:	$963,980.21
1. ASTs, API Separator, and Clarifiers Decommissioning					$30,000.00
2. Mobilization					$16,700.00
Assume	2	D6 Dozer delivery/pickup at	$1,200.00	each	$2,400.00
Assume	4	60' Trackhoe delivery/pickup at	$1,200.00	each	$4,800.00
Assume	1	Water Truck delivery/pickup at	$800.00	each	$800.00
Assume	4	210 Trackhoe delivery/pickup at	$1,200.00	each	$4,800.00
Assume	1	Office Trailer delivery/pickup at	$2,500.00	each	$2,500.00
Assume	4	6" pumps delivery/pickup at	$350.00	each	$1,400.00
3. Dewatering Ponds					$45,000.00
Assume	30	Pumps and crew	$1,500.00	per day	$45,000.00
4. Stabilizing Pond Sludge					$600,075.93
Assume	4,000	tons of portland cement	$126.00	per ton	$504,000.00
Assume	350	hours Long Stick Trackhoes at	$179.10	per hour	$62,685.93
Assume	40	hours Supervisor at	$60.00	per hour	$2,400.00
Assume	80	hours Laborers at	$28.00	per hour	$2,240.00
Assume	50	Mats at	$575.00	each	$28,750.00
5. Pond Area Grading					$60,728.00
Assume	400	hours Dozers at	$148.82	per hour	$59,528.00
Assume	20	hours Supervisor at	$60.00	per hour	$1,200.00
6. Topsoil Placement					$169,931.34
Assume	8,861	truck yards of top soil	$17.50	per truck yd	$155,067.50
Assume	90	hours D6 Dozer at	$149.82	per hour	$13,483.84
Assume	23	hours Supervisor	$60.00	per hour	$1,380.00
7. Revegetation					$41,544.95
Assume	198,809	sqft Hydromulch at	$0.11	per sqft	$20,874.95
Assume	1	irrigation water	$10,000.00	each	$10,000.00
Assume	1	irrgation system	$5,000.00	each	$5,000.00
Assume	300	hours Labor at	$18.90	per hour	$5,670.00
8. AMEC Project Oversight					$79,240.00
Assume	2	months Office Trailer at	$500.00	per month	$1,000.00
Assume	60	days Per Diem/Lodging at	$130.00	per day	$7,800.00
Assume	720	hours Senior Technician at	$86.00	per hour	$61,920.00
Assume	6	airfares	$470.00	per trip	$2,820.00
Assume	60	days vehicle rental at	$65	per day	$3,900
Assume	60	days vehicle fuel at	$30	per day	$1,800

Note: Demolition pricing from Alamo 1
AMEC Labor and Expense Pricing from Cedar Chemical 2009 Pricing Sheet
Volume and character of sludge to be stabilized is not known, these costs assume 5' of sludge typical thickness, approximately 20,000 cy sludge total.
Assumes pond areas re-graded using existing materials, with no import of backfill.
Assumes revegetation established in 3 months, all mowing and other maintenance by site owner/operator.